Final

Five-Year Review

Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina

Contract Task Order WE53

August 2015

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

NAVFAC CLEAN 8012 Program Contract N62470-11-D-8012



Prepared by



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FIVE-YEAR REVIEW REPORT

MARINE CORPS BASE CAMP LEJEUNE AND MARINE CORPS AIR STATION NEW RIVER **NORTH CAROLINA**

NAVFAC CLEAN 8012 PROGRAM CONTRACT N62470-11-D-8012 **CONTRACT TASK ORDER WE53**

AUGUST 2015

This report documents completion of the Five-Year Review of remedial actions implemented at Marine Corps Base Camp Lejeune and Marine Corps Air Station New River for Operable Units (OUs) 1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 16, 19, 20, 21, and 23, pursuant to section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended; the National Oil and Hazardous Substance Pollution Contingency Plan, 40 C.F.R. 300.430(f)(4)(ii); and all other applicable guidance. This document was prepared in coordination with Naval Facilities Engineering Command and provided to the U.S. Environmental Protection Agency and the North Carolina Department of Environment and Natural Resources for review and comment. This Five-Year Review is hereby approved.

1001	2 SEP ZO15
LD. WEIDLEY	Date

Brigadier General, U.S. Marine Corps

Commanding General

Approved by:

Marine Corps Installations East-Marine Corps Base, Camp Lejeune

T.M SALMON

Colonel, U.S. Marine Corps

Commanding Officer

Marine Corps Air Station New River



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4 ATLANTA FEDERAL CENTER 61 FORSYTH STREET ATLANTA, GEORGIA 30303-8960

SEP 1 6 2015

Commanding Officer
EMD, EQB
Marine Corps Base
PSC Box 20004
Camp Lejeune, North Carolina 28542

Dear Sir:

The U.S. Environmental Protection Agency Region 4 has reviewed the 2015 Five Year Review for Marine Corp Base Camp Lejeune, dated August 2015 and concur with the remedies selected for the seventeen operable units, which comprises twenty-six sites that remain protective of human health and the environment. The remedies are supported by the previously completed Remedial Investigation, Feasibility Study and Baseline Risk Assessment Reports. They are also supported by the review of the current applicable or relevant and appropriate requirements.

The EPA appreciates the coordination efforts of MCB Camp Lejeune and the level of effort that was put forth in developing this report. The EPA looks forward to continuing the exemplary working relationship with MCB Camp Lejeune and Atlantic Division Naval Facilities Engineering Command as we move toward a final cleanup of the National Priorities List Site.

If you have any questions, please contact Gena Townsend, of my staff, at (404) 562-8538.

Sincerely,

Franklin E. Hill, Director

Superfund Division

cc: Ms. Charity Delaney, Project Manager, Camp Lejeune

Mr. Dave Cleland, Project Manager, NAVFAC Atlantic

Mr. Randy McElveen, Project Manager, NCDENR

Executive Summary

The Department of the Navy (Navy), the lead agency, and Marine Corps Base (MCB) Camp Lejeune and Marine Corps Air Station (MCAS) New River conducted this Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Review (FYR) with regulatory oversight from the United States Environmental Protection Agency (USEPA) Region 4 and the North Carolina Department of Environment and Natural Resources (NCDENR). This is the fourth FYR for MCB Camp Lejeune and MCAS New River. The FYR was conducted in accordance with the *Comprehensive Five-Year Review Guidance* (USEPA, 2001) and supplements (USEPA, 2012a, 2012b), *Navy/Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Reviews* (Navy, 2011), the *Toolkit for Preparing Five-Year Reviews* (Navy, 2013), and the DoD *Defense Environmental Restoration Program (DERP) Management Manual* and 2014 Five-Year Review Procedures Update (DoD, 2012, 2014). This document summarizes the evaluation of remedial actions (RAs) that have been implemented at Operable Units (OUs) that resulted in hazardous substances, pollutants, or contaminants remaining at sites above levels that allow for unlimited use and unrestricted exposure (UU/UE), and for which there is a final Record of Decision (ROD) in place. The following 17 OUs are included in this FYR: OUs 1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 16, 19, 20, 21, and 23.

The objective of this FYR is to evaluate remedies at each OU to determine whether they remain protective of human health and the environment in accordance with the requirements set forth in their ROD. The protectiveness of the remedies was evaluated through reviews of technical reports, site visits and inspections, and community involvement activities. In addition, this FYR identifies issues, if any, that may be preventing a particular remedy from functioning as designed or as appropriate, or that could endanger the protection of human health and the environment.

A summary table of the OUs, associated sites, site descriptions, basis for action, site status, remedy components, recommendations and follow-up actions, protectiveness, and FYR status is provided as **Table ES-1**.

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Five-Year Review Summary Form

SITE IDENTIFICATION

Site name: Marine Corps Base Camp Lejeune and Marine Corps Air Station New River

EPA ID: NC6170022580

Region: 4 **State:** NC **City/County:** Onslow

SITE STATUS

NPL status: Final

Multiple OUs? Has the site achieved construction completion?

Yes No

REVIEW STATUS

Lead agency: Other Federal Agency

If "Other Federal Agency" was selected above, enter Agency name: Department of the Navy

Author name (Federal or State Project Manager): Naval Facilities Engineering Command, Mid-Atlantic

Review period: 3/24/2010 to 02/28/2015

Date of site inspection: 3/26/2014, 3/27/2014, and 9/30/2014

Type of review: Statutory

Review number: 4

Triggering action date: 08/30/2010

Due date (five years after triggering action date): 08/30/2015

ES120414012346RAL III

ISSUES/RECOMMENDATIONS

OU(s) without Issues/Recommendations Identified in the Five-Year Review:

OU 4, OU 7, OU 8, OU 11, OU 12, OU 13, OU 14, OU 16, OU 19, and OU 23

ISSUES/RECOMMENDATIONS

Issues and Recommendations Identified in the Five-Year Review:

The majority of the issues and recommendations are OU-specific. However, OUs with the same issue (i.e. LUCs or emerging contaminant evaluation) were grouped together.

OU(s): OU 1

Issue Category: Changed Site Conditions

Issue: The remedy is not functioning as designed and remedial action objectives (RAOs) will not be met within a reasonable timeframe because recently discovered source areas and deeper groundwater contamination are not being addressed.

Recommendation: Continue groundwater remedy evaluation to determine what changes are needed and refine the CSM to evaluate extent of groundwater contamination and exposure pathways. Develop a Revised Proposed Plan and ROD Amendment or explanation of significant differences (ESD) as necessary.

Affect Current Protectiveness	Affect Future Implementing Protectiveness Party		Oversight Party	Milestone Date	
No	Yes	Navy	USEPA/State	12/30/2020	

OU(s): OU 1, OU 2, OU

Issue Category: Monitoring

Issue: A regional screening level (RSL) was established for 1,4-dioxane and indicator constituents are present in groundwater.

Recommendation: Collect groundwater samples for 1,4-dioxane to evaluate presence/absence.

Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	Yes	Navy	USEPA/State	9/30/2018

OU(s): OU 1

Issue Category: No Issue

Issue: Cleanup levels were met at Site 24 and long-term monitoring is complete but remedy completion has not been formally documented.

Recommendation: Prepare a Remedial Action Completion Report (RACR) to document remedy completion at Site 24.

Affect Current Protectiveness	rotectiveness Protectiveness		Oversight Party	Milestone Date	
No	No	Navy	USEPA/State	6/30/2016	

IV ES120414012346RAL

ISSUES/RECOMMENDATIONS							
Issues and Recommendat The majority of the issues emerging contaminant ev	and recommendations a	re OU-specific. Howev	ver, OUs with the same	e issue (i.e. LUCs or			
OU(s): OU 1, OU 2, OU 6, OU 10, OU 21	Issue Category: Institutional Controls						
0, 00 10, 00 21	Issue: Potential for VI p	oathway.					
	Recommendation: Pre Industrial/Non-Industri	pare a Master ESD to al Use Control Bound	update RAOs to includ ary (VI).	e VI and add an			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date			
No	Yes	Navy	USEPA/State	6/30/2016			
OU(s): OU 2	Issue Category: Change	ed Site Conditions					
	Issue: Current extent o	f COCs in site media is	not fully assessed at S	Sites 6 and 82.			
	Recommendation: Complete assessment of the extent of chemicals of concern (COCs) in site media. Update groundwater land use controls (LUCs) as applicable.						
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date			
No	Yes	Navy	USEPA/State	Complete Assessment: 12/30/2016 Update LUCs: 12/30/2018			
OU(s): OU 2	Issue Category: Change	ed Site Conditions					
	Issue: COCs were detectindicating a potential to	cted in surficial ground ransport pathway fror	dwater and porewater n groundwater to surf	leading to Wallace Creek ace water.			
	Recommendation: Re-	evaluate human healt	h and ecological risks l	pased on updated data.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date			
No	Yes	Navy	USEPA/State	12/30/2016			
OU(s): OU 2	Issue Category: Institut	tional Controls					
	Issue: Explosive hazard	s may be present with	nin the boundary of UX	(0-22.			
	Recommendation: Pre LUCs to include an intro	pare a Master ESD to usive activities contro	update the OU 2 ROD I for munitions and exp	to include UXO-22. Add plosives of concern (MEC).			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date			
No	Yes	Navy	USEPA/State	6/30/2016			

ES120414012346RAL V

	ISSUE	S/RECOMMENDATI	ONS						
The majority of the issues	Issues and Recommendations Identified in the Five-Year Review: The majority of the issues and recommendations are OU-specific. However, OUs with the same issue (i.e. LUCs or emerging contaminant evaluation) were grouped together.								
OU(s): OU 2	Issue Category: Operat	ions and Maintenance	2						
	Issue: Effluent standard Federal criteria that ha	ds for the treatment sy s since been updated.	ystem were selected in	1993 based on State and					
	Recommendation: Re-evaluate effluent standards based on current State and Federal cri								
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date					
No	Yes	Navy	USEPA/State	12/30/2016					
OU(s): OU 2	Issue Category: Remed	y Performance							
	Issue: Existing treatment Site 82 or groundwater	nt system does not en contamination at Site	compass recently disco	vered source areas at					
	Recommendation: Evaluate expanding or modifying the existing treatment system at Site 82 and evaluate alternative treatment technologies at Sites 6 and/or Site 82 to remediate source areas and minimize degradation of Wallace Creek. Develop a Revised Proposed Plan and ROD Amendment or ESD as necessary.								
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date					
No	Yes	Navy	USEPA/State	12/30/2020					
OU(s): OU 5	Issue Category: No Issu	ie							
	Issue: Confirmation soi	l and sediment data de	oes not exceed residen	tial RSLs.					
	Recommendation: Remove non-industrial use LUC because post-removal confirmation samples do not exceed residential risk-based levels and prepare a RACR.								
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date					
No	No	Navy	USEPA/State	6/30/2016					

VI ES120414012346RAL

ISSUES/RECOMMENDATIONS Issues and Recommendations Identified in the Five-Year Review: The majority of the issues and recommendations are OU-specific. However, OUs with the same issue (i.e. LUCs or emerging contaminant evaluation) were grouped together. OU(s): OU 6 **Issue Category:** Monitoring Issue: Groundwater modeling, as defined by the ROD, may not be appropriate for evaluating monitored natural attenuation (MNA) and protection of Brinson Creek at Site 36. Recommendation: Discontinue BIOCHLOR modeling and surface water sampling as part of LTM; compare groundwater data collected from the most downgradient locations closest to Brinson Creek to 10 times the NCSWQS to monitor future protectiveness of Brinson Creek. If there are exceedances, surface water will be sampled. Affect Current Affect Future **Implementing Oversight Party** Milestone Date **Protectiveness Protectiveness Party** No USEPA/State 9/30/2016 Yes Navy OU(s): OU 6 **Issue Category:** Monitoring Issue: Perfluorinated compounds (PFCs) are an emerging contaminant group for former firefighting/burn pits and Site 54 is a former firefighting training area. **Recommendation:** Collect groundwater samples for PFCs. Affect Current Affect Future **Implementing** Milestone Date **Oversight Party Party Protectiveness Protectiveness** No USEPA/State 12/30/2017 Yes Navy

PR	OTEC	TIVEN	ESS ST	TATEN	IENT(S)
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Operable Unit: Protectiveness Determination: Addendum Due Date

OU 1, OU 2, OU 6, OU 10, OU Short-term Protective (if applicable):
20, OU 21 Not applicable

Protectiveness Statement:

The protectiveness statements for each OU are included in Sections 3 through 19, as applicable, and summarized in Table ES-1.

Operable Unit: Protectiveness Determination: Addendum Due Date

OU 4, OU 5, OU 7, OU 8, OU 11, Protective (*if applicable*):
OU 12, OU 13, OU 14, OU 16,
OU 19, OU 23

(if applicable):
Not applicable

Protectiveness Statement:

The protectiveness statements for each OU are included in Sections 3 through 19, as applicable, and summarized in Table ES-1.

ES120414012346RAL VII

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	Protectiveness	Recommendations (Milestones)	Next Review
1	21 24 78	Transformer Storage Lot 140 Industrial Area Fly Ash Dump Hadnot Point Industrial Area	ROD-1994 ESD-1995 LUCIP-2001/2002 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014 ROD-1994 Final LTM Report-2001 Five-Year Review-2010 Site Visit-2014 Base Master Planning GIS-2014 ROD-1994	1994 - ROD signed for soil removal and LUCs 1995 - ESD for PCB cleanup levels 1995 - Soil Removal Action 2001/2002 - LUCs 1994 - ROD signed for LTM 1996-1998 - LTM 2001 - NFA documented in LTM report	To treat or remove contaminated soil from designated areas of concern. To prevent current or future exposure to the contaminated groundwater and soils. To remediate groundwater contamination for future potential use of the aquifer. Proposed: Prevent future exposure to COCs in indoor air via the VI pathway.	-Soil removal to industrial levels (complete) -Non-Industrial Use Control - Soil -LTM of groundwater (complete) -Soil removal to industrial levels (complete)	The remedy for soil at OU 1 is protective of human health and the environment because exposure pathways that could result in unacceptable risk are being controlled and LUCs preventing exposure are in place. The remedy for groundwater at OU 1 currently protects human health and the environment in the short-term	-Prepare a RACR to document remedy completion (6/30/2016) -Prepare a Master ESD to update RAOs to include VI and add an	2020 No further reviews 2020
			LUCIP-2001/2002, 2015 O&M Data-2010-2014 LTM Reports-2010-2013 VI Reports-2009/2011/2015 Five-Year Review-2010 LUC Inspections-2010-2014 Supplemental Investigation-2013 LTM Data-2014 Site Visit-2014 Base Master Planning GIS-2014	Extraction and Treatment, LTM, and LUCs 1995 - Soil Removal Action 1995-present - Groundwater Treatment and LTM 2001/2002 - LUCs 2015 - LUCs updated		-Groundwater Extraction and Treatment System -LTM of groundwater -Non-Industrial Use Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet) -Proposed: Industrial/Non-Industrial Use Control (VI)	revisited to address the current extent of groundwater contamination.	industrial/non-industrial use control boundary (VI) (6/30/2016) -Collect groundwater samples for 1,4-dioxane to evaluate presence/absence (9/30/2018) -Continue groundwater remedy evaluation to determine what changes are needed and refine the CSM to evaluate extent of groundwater contamination and exposure pathways. Develop a Revised Proposed Plan and ROD Amendment or explanation of significant differences (ESD) as necessary (12/30/2020)	
2	6	Storage Lots 201 and 203	ROD-1993 LUCIP-2001/2002 LTM Reports-2010-2013 VI Reports-2009/2011/2015 Five-Year Review-2010 LUC Inspections-2010-2014 Supplemental Investigations-2011-2014 LTM Data-2014 Site Visit-2014 Base Master Planning GIS-2014	1993 - ROD signed for OU 2 Soil Removal, SVE, Groundwater Extraction and Treatment, LTM, and LUCs 1994-1995 - Soil Removal Action 1996-present - LTM 2001/2002 - LUCs 2011 - TCRA to remove chlorobenzene drums	Prevent current and future exposure to contaminated soil and groundwater. Remediate groundwater for future use. Treat or remove contaminated soil. Proposed: Prevent future exposure to COCs in indoor air via the VI pathway. Proposed: Reduce or prevent the potential for direct physical contact with MEC/MPPEH.		The remedies for soil and groundwater at OU 2 are protective of human health and the environment in the short-term because LUCs are in place to prevent exposure. Soil LUCs are in place to prevent exposure. Soil LUCs are in place to restrict intrusive activities and non-industrial use and will be updated to include MEC. Groundwater LUCs are in place to prevent exposure to COCs and will be updated to reflect the current extent of COCs and to include mitigation of future VI pathways. To facilitate protectiveness, Base Master Planning maintains all current VOC plume data and MMRP site boundaries in the GIS and all construction projects go through environmental review. In order for the remedy to be protective in the long-term, supplemental site investigations should be completed to define the extent of source material and COCs in groundwater. This information will then be used to update	-Complete assessment of the extent of COCs in site media (12/30/2016) and update groundwater LUCs as applicable	2020
	82	Piney Green Road VOC Area	LUCIP-2001/2002 Groundwater Extraction and Treatment, LTN 0&M Data-2010-2014 1994-1995 - Soil Removal Action LTM Reports-2010-2013 1996 - SVE	996 - SVE 996-present - Groundwater Treatment and LTM		-Soil removal to industrial levels -SVE -Groundwater Extraction and Treatment System -LTM of groundwater and surface water -Non-Industrial Use Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet) -Proposed: Industrial/Non-Industrial Use Control (VI) -Proposed: Intrusive Activities Control - MEC	the RAOs and the site remediation strategy to address groundwater contamination and mitigate degradation of Wallace Creek.	-Collect groundwater samples for 1,4-dioxane to evaluate presence/absence (9/30/2018) -Evaluate expanding or modifying the existing treatment system at Site 82 and evaluate alternative treatment technologies at Sites 6 and 82 to remediate source areas and minimize degradation of Wallace Creek. Develop a revised Proposed Plan and ROD Amendment or ESD as necessary (12/30/2020)	2020
4	41	Camp Geiger Dump near Former Trailer Park	ROD-1995 LUCIP-2001/2002 IRACR-2006 LTM Report-2001 Closeout Report-2006 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	1995 - ROD signed for LTM and LUCs 1997-2005 - LTM of groundwater, surface water, and sediment 2001/2002 - LUCs 2006 - NFA 2008 - Fence Installed	Prevent exposure to contaminated soils and former disposal area materials. Prevent future potential exposure to contaminated groundwater.	-LTM of groundwater (complete) -LTM of surface water and sediment (complete) -Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (500 feet) -Site Access Control	The remedy at OU 4 is protective of human health and the environment. Perimeter fencing restricts access to the waste areas at Sites 41 and 74. The LUCs to restrict intrusive activities, aquifer use, and non-industrial use at the sites are protective because exposure pathways to waste that could result in unacceptable risks are being controlled. Groundwater LTM is determined complete because the detected concentrations from the final four rounds of LTM were below the cleanup levels and this remains protective	e	2020
	74	Mess Hall Grease Dump Area	ROD-1995 Final LTM Report-2001 LUCIP-2001/2002 Five-Year Review-2010 Closeout Report-2006 LUC Inspections-2010-2014 Henderson/Hickory Pond Investigations-2012-2013 Site Visit-2014 Base Master Planning GIS-2014	1995 - ROD signed for LTM and LUCs 1997-1998 - LTM 2001-present - LUCs 2006 - NFA 2011 - Fence installed		-LTM of groundwater (complete) -Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (500 feet) -Site Access Control	because the detected concentrations were below the current standards and there is no current or potential future exposure. Surface water and sediment LTM at Site 41 is determined complete because COCs in groundwater are below current standards, and potential future discharge of groundwater to surface water will not be impacted.		2020

ου	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	Protectiveness	Recommendations (Milestones)	Next Review
5	2	Former Nursery/Day Care Center	ROD-1994 TCRA Closeout Report-1995 LUCIP-2001/2002/2009 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Closeout Report-2008 Update to Closeout Report-2011 Base Master Planning GIS-2014	1994-TCRA 1994 - ROD signed for LTM and LUCs 1997-2007 - LTM 2001-present - LUCs 2009 - LUCs updated	TCRA RAO: Remove soil and sediment with concentrations of pesticides that present a potential risk to human health and the environment. ROD RAOs: Prevent future human exposure to the contaminated groundwater. Insure, through monitoring, that there are no human or environmental exposures due to migration of the contaminant plume off site.	-Soil and sediment removal to industrial levels (complete) -LTM of groundwater (complete) -Non-Industrial Use Control - Soil -Intrusive Activities Control - Groundwater (removed in 2009) -Aquifer Use Control (1000 feet) (removed in 2009)	The remedy at OU 5 is protective of human health and the environment because cleanup levels for UU/UE have been achieved. Groundwater LTM is complete because cleanup levels for COCs have been met, furthermore soil concentrations in confirmation samples after the TCRA are below residential RSLs.	-Remove non-industrial use LUC because post-removal confirmation samples do not exceed residential risk-based levels and prepare a RACR (6/30/2016)	2020
6	36	Camp Geiger Dump Area Near Sewage Treatment Plant	ROD-2005 LUCIP-2005 Five-Year Review-2010 LUC Inspections-2010-2014 LTM Reports-2010-2013 Site Visit-2014 LTM Data-2014 Base Master Planning GIS-2014	2005 - ROD signed for MNA and LUCs 1998-present - MNA 2005 - LUCs	Protect human health by preventing exposure to surface and subsurface soil within the following areas: lead contaminated areas, and unknown disposal materials within the former dump, and the previous soil removal action areas (i.e., PCB, PAH and pesticide removal action areas). Prevent future exposure to VOC-contaminated groundwater and assess natural attenuation of groundwater contamination. Protect uncontaminated groundwater for future potential beneficial use. Proposed: Prevent future exposure to COCs in indoor air via the VI pathway.	-LTM of surface water and groundwater MNA -Annual groundwater modeling -Non-Industrial Use Control -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet) -Proposed: Industrial/Non-Industrial Use Control (VI)	The remedy at OU 6 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled and LUCs preventing exposure to waste, soil, and groundwater are in place. At Site 36, LTM is ongoing to monitor the VOC plume and migration and LUCs are in place to restrict groundwate intrusive activities and prohibit aquifer use until cleanup levels are achieved. LUCs are in place to prohibit non-industrial use within the extent of the former soil removal action areas at Sites 36, 43, 44, and 54 where possible debris, PAHs, PCBs, and/or lead remain in soil above levels that allow for UU/UE. Because of the former dumping and/or burning activities, LUCs are also in place at Sites 43, 44, and 54 to restrict intrusive activities.	-Prepare a Master ESD to update RAOs to include VI and add an industrial/non-industrial use control boundary (VI) (6/30/2016) -Discontinue BIOCHLOR modeling and surface water sampling as part of LTM; compare groundwater data collected from the most downgradient locations closest to Brinson Creek to 10 times the NCSWQS to monitor future protectiveness of Brinson Creek; if there are exceedances, surface water will be sampled (9/30/2016)	2020
	43	Agan Street Dump	ROD-2005 LUCIP-2005 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	2005 - ROD signed for LUCs 2005 - LUCs	Prevent future exposure to the surface and subsurface soil within the former site wide dump from unknown disposed materials and the previous soil removal action area (i.e., PAH removal action area).	-Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil		None	2020
	44	Jones Street Dump	ROD-2005 LUCIP-2005 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	2005 - ROD signed for LUCs 2005 - LUCs	Prevent future exposure to the surface and subsurface soil due to unknown disposed materials within the former site wide dump.	-Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil		None	2020
	54	Crash Crew Fire Training Burn Pit	ROD-2005 LUCIP-2005 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	2005 - ROD signed for LUCs 2005 - LUCs	Prevent future exposure to the surface and subsurface soil within the former burn pit area.	-Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil		-Collect groundwater samples for PFCs (12/30/2017)	2020
7	7 1	French Creek Liquids Disposal Area	ROD-1996 LUCIP-2001/2002 RACR-2002 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014 RACR-2015	1996 - ROD signed for LTM and LUCs 1996-2001 - LTM 2001-2015 - LUCs 2015 - Remedy Complete	Prevent current and future exposure to contaminated groundwater. Protect uncontaminated water for future potential use.	-LTM of groundwater (complete) -Non-Industrial Use Control - Soil (removed in 2015) -Intrusive Activities Control - Groundwater (removed in 2015) -Aquifer Use Control (1000 feet) (removed in 2015)	The remedy is complete at Site 1 and a RACR is being prepared to document completion. The remedy at Site 28 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through LUCs to restrict intrusive activities, non-industrial use, and aquifer use.	None	No further reviews
	28	Hadnot Point Burn Dump	ROD-1996 LUCIP-2001/2002/2014 RACR-2002 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	1996 - ROD signed for LTM and LUCs 1996-2001 - LTM 2001-present - LUCs 2014 - LUCs updated		-LTM of groundwater (complete) -Non-Industrial Use Control - Waste -Intrusive Activities Control - Waste -Aquifer Use Control (1000 feet)			2020

ου	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	Protectiveness	Recommendations (Milestones)	Next Review
8	16	Former Montford Point Burn Dump	ROD-1996 LUCIP-2001/2002/2014 Five-Year Review-2010 LUC Inspections-2010-2014 ESD-2012 Site Visit-2014 Base Master Planning GIS-2014	1996 - ROD signed for NFA 2001-present - LUCs implemented based on use as a former dump 2012 - ESD to include LUCs as the final remedy 2014 - LUCs updated	Prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.	-Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet)	The remedy at OU 8 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit non-industrial land use and restrict intrusive activities within the waste disposal area, prohibit the withdrawal and any use of the groundwater, except for environmental monitoring, from the aquifers (surficial and Castle Hayne) within 1,000 feet of the site, and to restrict intrusive activities below the shallow groundwater table.	None	2020
10	35	Camp Geiger Fuel Farm	Five-Year Review-2010 NTCRA Report-2008 RI-2009 FS-2009 ROD-2009 VI Reports-2009/2011/2015 RD-2009 LTM Reports-2010-2013 IRACR-2011 Base Master Planning GIS-2014 Site Visit-2014 LTM Data-2014	1995 - Interim ROD signed for in-situ AS trench 1998-2009 - In-situ AS trench 1999-2004 - LTM 2009 - ROD signed for horizontal AS, LTM/MNA, and LUCs 2010-2012 - AS	Restore groundwater quality at Site 35 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent human ingestion of water containing COCs (benzene, 1,1,2,2-PCA, PCE, TCE, cis-1,2-DCE, and VC) at concentrations exceeding NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained. Minimize migration of COCs in groundwater to surface water. Proposed: Prevent future exposure to COCs in indoor air via the VI pathway.	-AS using horizontal wells (complete) -LTM of groundwater for MNA -Aquifer Use Control (1000 feet) -Proposed: Industrial/Non-Industrial Use Control (VI)	The remedy for groundwater at OU 10 is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled through LUCs for groundwater. The Base maintains all current COC plumes in GIS and Master Planning processes to prevent unacceptable exposure for potential VI pathways. MNA is ongoing to monitor groundwater COCs and LUCs to prohibit aquifer use and exposure to COCs are in place until cleanup levels are achieved.	-Prepare a Master ESD to update RAOs to include VI and add an industrial/non-industrial use control boundary (VI) (6/30/2016)	2020
11	80	Paradise Point Golf Course Maintenance Area	TCRA Closeout Report-1996 ROD-1997 LUCIP-2007 Five-Year Review-2010 LUC Inspections-2010-2014 ESD-2012 Site Visit-2014 Base Master Planning GIS-2014	1997 - ROD signed for NFA 2007 - LUCs implemented based on former soil removal to industrial levels 2012 - ESD to include LUCs as the final remedy	Prevent exposure to pesticides in soil.	-Non-Industrial Use Control - Soil -Intrusive Activities Control - Soil	The remedy at OU 11 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through LUCs. LUCs are in place to restrict soil intrusive activities and prohibit non-industrial use within the extent of the former soil removal action areas where pesticides remain in soil above levels that allow for UU/UE.	None	2020
12	3	Old Creosote Plant	ROD-1997 ROD Amendment-2000 LUCIP-2001/2002 VI Report-2009 LTM Reports-2010-2013 Five-Year Review-2010 LUC Inspections-2010-2014 LTM Data-2014 Site Visit-2014 Base Master Planning GIS-2014	1997 - ROD signed for source removal and biological treatment, LTM, LUCs 1997-present - LTM 2000 - ROD Amendment for soil removal, LTM, LUCs 2001/2002 - LUCs	Prevent leaching of PAH contaminants from subsurface soil to groundwater. Remediate subsurface soil and shallow groundwater. Prevent exposure to PAH contaminated groundwater.	-Soil removal to NC SSLs (complete) -LTM of groundwater -Non-Industrial Use Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet)	The remedy at OU 12 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled. LTM is ongoing to monitor the SVOC concentrations and LUCs are in place to restrict intrusive activities, non-industrial land use, and aquifer use until groundwater cleanup levels are achieved.	None	2020
13	63	Verona Loop Dump	ROD-1997 LUCIP-2001/2002 Five-Year Review-2010 LUC Inspections-2010-2014 ESD-2012 LUCIP-2014 Site Visit-2014 Base Master Planning GIS-2014	1997 - ROD signed for NFA 2001/2002 - LUCs implemented based on use as a former dump 2012 - ESD to include LUCs as the final remedy 2013 - LUCIP to include restrictions for intrusive activities and non-industrial use	Prevent exposure to waste.	-Non-industrial Use and Instrusive Activities Control - Soil -Intrusive Activities Control - Soil -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet)	The remedy at OU 13 is protective of human health and the environment and exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to restrict soil and groundwater intrusive activities and aquifer use.	None	2020

ου	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	Protectiveness	Recommendations (Milestones)	Next Review
14	69	Rifle Range Chemical Dump	Interim ROD-2000 LUCIP-2001/2002 Five-Year Review-2010 Supplemental Investigation Report-2011 LUC Inspections-2010-2014 ROD-2013 Site Visit-2014 No Action Decision Document (UXO-02)-2013 After Action Report (UXO-02)-2013 RD-2013 Base Master Planning GIS-2014	2000 - Interim ROD signed for LTM and LUCs 1998-2005 - LTM 2001/2002 - LUCs 2013 - Final ROD signed for multi-layered cap, LTM, and LUCs 2014 - Cap construction complete 2015 - LTM	Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Minimize exposure to potential chemical agent and chemical waste to the maximum extent practicable. Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable. Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE. Minimize potential degradation of the New River by COC-affected groundwater.	-Construction of a multi-layered cap (complete) -LTM of groundwater for MNA and contaminant migration monitoring -Industrial/Non-Industrial Use Control (VI) -Intrusive Activities Control - Soil, Groundwater -Aquifer Use Control (1000 feet) -Site Access Control	The remedy at OU 14 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through the cap and LUCs. Perimeter fencing restricts access to the waste area at Site 69. The LUCs to restrict soil and groundwater intrusive activities and prohibit non-industrial and aquifer use are protective of human health and the environment because exposure to waste, soil, and groundwater that could result in unacceptable risks is being controlled. MNA will be initiated to monitor plume stability and confirm that there are no releases from the waste disposal area or potential impacts to surface water.	None	2020
16	89	Former DRMO	RI-2008 Treatability Study Report-2008 NTCRA (Soil Mixing)-2009 NTCRA (Western Wetland)-2010 ROD/RD-2012 VI Reports-2009/2011/2015 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Interim RACR (PRB/aerators)-2014 Interim RACR (AS)-2014 LTM Data-2014 Base Master Planning GIS-2014	1999-2005 - LTM 2008 - NTCRA for Soil Mixing with ZVI 2010 - NTCRA for Soil/Sediment removal in Western Wetland 2012 - ROD for AS in groundwater, downgradient PRB, surface water aerators, LTM of groundwater (MNA) and surface water, and LUCs 2013-present - AS 2014-present - PRBs, surface water aerators, MNA, LUCs	Restore groundwater quality at Site 89 to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A NCAC 02L.0201. Minimize degradation of Edwards Creek from COC-impacted groundwater discharging into surface water until surface water COC concentrations meet the NCSWQS. Control exposure to COCs in groundwater and VI from COCs in groundwater.	-AS using horizontal wells -Permeable reactive barrier to treat downgradient groundwater -Surface water aerators -LTM of groundwater for MNA and performance monitoring -LTM of surface water -Soil vapor monitoring during AS -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet) -Industrial/Non-Industrial Use Control (VI) -Access Control	The remedy at OU 16 for groundwater and surface water will be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. The LUCs are in place to prevent exposure to groundwater, vapor intrusion, and surface water and therefore there is no current exposure. Active remediation is currently being implemented at Site 89 to reduce the contaminant mass in groundwater and surface water; MNA is currently implemented at Site 93 and a pilot study is being implemented to evaluate enhanced reductive dechlorination.	None	2020
	93	Building TC-942	FS-2005 ROD-2006 RDs-2006 Construction Completion Report-2008 LUCIP-2009/2014 IRACR-2009 VI Reports-2009/2011/2015 Five-Year Review-2010 LTM Reports-2010-2013 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	1999-2005 - LTM 2006 - ROD signed for ISCO, MNA, LUCs 2006-2008 - ISCO to treat VOCs in groundwater 2008-present - LTM 2009-present - LUCs	Reduce COC concentrations in the highest concentration areas and reduce exceedances of COCs to meet the NCGWQS or MCLs, whichever is more conservative Prevent human exposure of water containing COCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) at concentrations above NCGWQS or MCLs, whichever is more conservative Achieve suitability of Site 93 groundwater for UU/UE with a reasonable approach and within a reasonable timeframe	-ISCO using permanganate (complete) -LTM of groundwater for MNA -Intrusive Activities Control - Groundwater -Aquifer Use Control (1000 feet) -Industrial/Non-Industrial Use Control (VI)		None	2020
19	84	Building 45	ROD-2009 RD-2009 Five-Year Review-2010 LUC Inspections-2010-2014 Site Visit-2014 Base Master Planning GIS-2014	2002-2006 - Soil Removal Actions 2009 - ROD signed for soil removal and LUCs 2009 - LUCs	Remove contaminated surface and subsurface soils that contain PCBs in excess of the selected remediation goal (i.e., cleanup level) and prevent exposure to remaining PCB contaminated soil consistent with the requirements for a low occupancy industrial area.		The remedy for soil at OU 19 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit soil intrusive activities and prohibit non-industrial use within the extent of the former soil removal action areas where PCBs remain in soil above levels that allow for UU/UE. A fence and signs were also installed to restrict access within the areas of PCB contamination greater than 10 mg/kg in subsurface soils.		2020

Five-Year Review Summary Table

2015 Five-Year Review

Camp Lejeune, North Carolina

ου	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	Protectiveness	Recommendations (Milestones)	Next Review
20	86	Tank Area AS419-AS421	Expanded Supplemental RI-2011 FS-2013 ROD-2014 Site Visit-2014 Base Master Planning GIS-2014	2014 - ROD signed for MNA and LUCs	Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE.	-LTM of groundwater for MNA -Aquifer Use Control -Industrial/Non-Industrial Use Control (VI) -Intrusive Activities Control	The remedy at OU 20 will be protective of human health and the environment when it is implemented because exposure pathways that could result in unacceptable risks will be controlled by LUCs preventing exposure to groundwater COCs. MNA to monitor the VOC plume and LUCs will be implemented in 2015 to prohibit non-industrial and aquifer use until cleanup levels are achieved. To facilitate protectiveness, Base Master Planning maintains all current VOC plume data in the GIS and all construction projects go through environmental review.		2020
21	73	Amphibious Vehicle Maintenance Facility	Pilot Study Report-2008 RI-2009 FS-2009 ROD-2009 Five-Year Review-2010 VI Reports-2009/2015 RD-2010 LTM Reports-2010-2014 IRACR (AS)-2011 IRACR (biobarrier)-2011/2014 LTM Data-2014 Site Visit-2014 Base Master Planning GIS-2014	2000-2005 - LTM 2009 - ROD signed for horizontal AS and downgradient ERD injections, MNA, and LUCs 2010-present - MNA and LUCs 2010-2012 - AS 2011 - First biobarrier injection event 2013 - Second biobarrier injection event	Restore groundwater quality at Site 73 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent human ingestion of water containing COCs (benzene, TCE, cis-1,2-DCE, 1,1-DCE, and VC) at concentrations above NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained. Prevent future residential exposure to petroleum hydrocarbon-contaminated soils above the NC SSL and minimize transport to groundwater. Minimize migration of COCs in groundwater to surface water. Proposed: Prevent future exposure to COCs in indoor air via the VI pathway.	-AS using a horizontal well (complete) -Downgradient ERD injections -LTM of groundwater for MNA -Aquifer Use Control (1000 feet) -Intrusive Activities Control - Soil -Proposed: Industrial/Non-Industrial Use Control (VI)	The remedy for groundwater and soil at OU 21 will be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled through LUCs for groundwater. The Base maintains all current COC plumes in GIS and Master Planning processes to prevent unacceptable exposure for potential VI pathways. The horizontal AS system has treated the highest VOC concentrations in groundwater and substrate injections will be continued to prevent impact to the adjacent surface water body. LUCs to prohibit aquifer use and intrusive soil activities are in place until cleanup levels for UU/UE are achieved.	-Prepare a Master ESD to update RAOs to include VI and add an industrial/non-industrial use control boundary (VI) (6/30/2016)	2020
23 Notes:	49	MCAS Suspected Minor Dump	PA/SI-2011 RI/FS-2012 ROD-2014 RD-2014 IRACR-2014 LTM Data-2014	2014 - ROD signed for MNA and LUCs 2014-present - MNA and LUCs	Restore groundwater quality to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE. Minimize potential degradation of the New River by COC-affected groundwater.	-LTM of groundwater for MNA -LTM of pore water -Industrial/Non-Industrial Use Control (VI) -Aquifer Use Control (1,000 feet)	The remedy for groundwater at OU 23 will be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. LTM to monitor groundwater COCs and LUCs to prohibit aquifer use and mitigate VI are in place until cleanup levels for UU/UE are achieved.	None	2020

AS - air sparging

COC - chemical of concern CSM - conceptual site mod

DCE - dichloroethene
DRMO - Defense Reutilization and Marketing Office

ERD - enhanced reductive dechlorination

ESD - Explanation of Significant Differences

FS - Feasibility Study
GIS - geographic information system

IRACR - Interim Remedial Action Completion Report

ISCO - in-situ chemical oxidation

LTM - long-term monitoring LUC - land use control

LUC - land use control
LUCIP - Land Use Control Implementation Plan
MCAS - Marine Corps Air Station

MCL - maximum contaminant level
MEC - munitions and explosives of concern
MMA - monitored natural attenuation
NC SSL - North Carolina Soil Screening Level

NCAC - North Carolina Administrative Code

NCGWQS - NC 2L Groundwater Quality Standards NFA - No Further Action NTCRA - non-time-critical removal action O&M - operations and maintenance

O&M - operations and maintenance
OU - Operable Unit
PA - preliminary assessment
PAH - polycyclic aromatic hydrocarbon
PCA - tetrachloroethane

PCB - polychlorinated biphenyls
PCE - tetrachloroethene
PFC - perfluorinated compounds
PRB - permeable reactive barrier
RACR - Remedial Action Completion Report

RAO - remedial action objective RD - Remedial Design RI - Remedial Investigation ROD - Record of Decision

RSL - regional screening level
SI - site inspection
SVE - soil vapor extraction
TCE - trichloroethene
TCRA - time-critical removal action
UU/UE - unlimited use/unrestricted exposure
UXO - unexploded ordnance

VC - vinyl chloride VI - vapor intrusion

VOC - volatile organic compound

Contents

Exec	Executive Summaryi				
Acro	nyms an	nd Abbreviations	xix		
1	Intro	oduction	1-1		
	1.1	Objectives and Approach	1-1		
	1.2	Installation Background			
		1.2.1 Regional Water Use			
		1.2.2 Environmental Restoration Program			
	1.3	Operable Units and Sites			
	1.4	Report Organization			
	1.5	References			
2	Five-	-Year Review Process	2-1		
	2.1	Document Review	2-1		
		2.1.1 Risk Review	2-1		
		2.1.2 Emerging Contaminants	2-1		
	2.2	Site Inspections	2-2		
	2.3	Community Involvement	2-2		
	2.4	Interviews	2-2		
	2.5	Next Five-Year Review	2-2		
	2.6	References	2-2		
3	Oper	rable Unit 1 (Sites 21, 24, and 78)	3-1		
	3.1	Site History and Background	3-1		
	3.2	Site Characterization	3-2		
		3.2.1 Physical Characteristics	3-2		
		3.2.2 Land Use	3-2		
		3.2.3 Site Characterization and Risk Assessment Results	3-2		
		3.2.4 Interim Removal Actions	3-3		
	3.3	Remedial Action Objectives	3-3		
	3.4	Remedial Actions	3-3		
	3.5	Remedy Implementation	3-4		
		3.5.1 Remedy Operation and Maintenance	3-4		
		3.5.2 Post-ROD Removal Actions and Pilot Studies			
		3.5.3 Progress Since the 2010 Five-Year Review	3-6		
	3.6	Technical Assessment			
	3.7	Issues, Recommendations, and Follow-up Actions	3-10		
	3.8	Statement of Protectiveness	3-11		
	3.9	References	3-11		
4	Operable Unit 2 (Sites 6, 9, and 82)				
	4.1	Site History and Background			
	4.2	Site Characterization			
		4.2.1 Physical Characteristics			
		4.2.2 Land Use			
		4.2.3 Site Characterization and Risk Assessment Results			
	4.3	Remedial Action Objectives			
	4.4	Remedial Actions			
	4.5	Remedy Implementation	4-3		

		4.5.1 Remedy Operation and Maintenance	4-4				
		4.5.2 Post-ROD Removal Actions and Pilot Studies	4-6				
		4.5.3 Progress Since the 2010 Five-Year Review	4-6				
	4.6	Technical Assessment	4-9				
	4.7	Issues, Recommendations, and Follow-up Actions	4-10				
	4.8	Statement of Protectiveness					
	4.9	References	4-11				
5	Oper	rable Unit 4 (Sites 41 and 74)	5-1				
	5.1	Site History and Background					
	5.2	Site Characterization	5-1				
		5.2.1 Physical Characteristics	5-1				
		5.2.2 Land Use	5-1				
		5.2.3 Site Characterization and Risk Assessment Results	5-2				
	5.3	Remedial Actions Objectives	5-2				
	5.4	Remedial Actions	5-2				
		5.4.1 Remedy Implementation	5-2				
		5.4.2 Remedy Operation and Maintenance	5-3				
		5.4.3 Progress Since the 2010 Five-Year Review	5-3				
	5.5	Technical Assessment	5-4				
	5.6	Issues, Recommendations, and Follow-up Actions	5-5				
	5.7	Statement of Protectiveness	5-5				
	5.8	References	5-5				
6	Oper	Operable Unit 5 (Site 2)					
	6.1	Site History and Background	6-1				
	6.2	Site Characterization	6-1				
		6.2.1 Physical Characteristics					
		6.2.2 Land Use					
		6.2.3 Site Characterization and Risk Assessment Results					
		6.2.4 Interim Removal Actions					
	6.3	Remedial Action Objectives					
	6.4	Remedial Actions	6-2				
		6.4.1 Remedy Implementation					
		6.4.2 Remedy Operation and Maintenance					
		6.4.3 Progress Since the 2010 Five-Year Review	6-3				
	6.5	Technical Assessment					
	6.6	Issues, Recommendations, and Follow-up Actions					
	6.7	Statement of Protectiveness					
	6.8	References	6-4				
7	Oper	rable Unit 6 (Sites 36, 43, 44, and 54)					
	7.1	Site History and Background	7-1				
	7.2	Site Characterization					
		7.2.1 Physical Characteristics	7-1				
		7.2.2 Land Use					
		7.2.3 Site Characterization and Risk Assessment Results	7-2				
		7.2.4 Interim Removal Actions					
	7.3	Remedial Action Objectives	7-4				
	7.4	Remedial Actions	7-4				
		7.4.1 Remedy Implementation					
		7.4.2 Remedy Operation and Maintenance	7-5				

		7.4.3 Progress Since the 2010 Five-Year Review	7-6
	7.5	Technical Assessment	
	7.6	Issues, Recommendations, and Follow-up Actions	7-8
	7.7	Statement of Protectiveness	7-8
	7.8	References	7-8
8	Opera	able Unit 7 (Sites 1, 28, and 30)	8-1
	8.1	Site History and Background	
	8.2	Site Characterization	8-1
		8.2.1 Physical Characteristics	8-1
		8.2.2 Land Use	8-2
		8.2.3 Site Characterization and Risk Assessment Results	8-2
	8.3	Remedial Action Objectives	8-2
	8.4	Remedial Actions	8-2
		8.4.1 Remedy Implementation	8-3
		8.4.2 Remedy Operation and Maintenance	8-3
		8.4.3 Progress Since the 2010 Five-Year Review	8-4
	8.5	Technical Assessment	8-4
	8.6	Issues, Recommendations, and Follow-up Actions	8-5
	8.7	Statement of Protectiveness	8-5
	8.8	References	8-5
9	Opera	able Unit 8 (Site 16)	9-1
	9.1	Site History and Background	9-1
	9.2	Site Characterization	9-1
		9.2.1 Physical Characteristics	9-1
		9.2.2 Land Use	9-1
		9.2.3 Site Characterization and Risk Assessment Results	9-1
	9.3	Remedial Action Objectives	9-2
	9.4	Remedial Actions	9-2
		9.4.1 Remedy Implementation	9-2
		9.4.2 Remedy Operation and Maintenance	
		9.4.3 Progress Since the 2010 Five-Year Review	
	9.5	Technical Assessment	
	9.6	Issues, Recommendations, and Follow-up Actions	9-3
	9.7	Statement of Protectiveness	9-3
	9.8	References	9-4
10	Opera	able Unit 10 (Site 35)	
	10.1	Site History and Background	
	10.2	Site Characterization	
		10.2.1 Physical Characteristics	
		10.2.2 Land Use	
		10.2.3 Site Characterization and Risk Assessment Results	
		10.2.4 Interim Removal Actions	
	10.3	Remedial Action Objectives	
	10.4	Remedial Actions	
	10.5	Remedy Implementation	
		10.5.1 Remedy Operation and Maintenance	
		10.5.2 Progress since the 2010 Five-Year Review	
	10.6	Technical Assessment	
	10.7	Issues, Recommendations, and Follow-up Actions	10-6

	10.8	Statement of Protectiveness	10-6
	10.9	References	10-6
11	Opera	able Unit 11 (Sites 7 and 80)	11-1
	11.1	Site History and Background	
	11.2	Site Characterization	
		11.2.1 Physical Characteristics	11-1
		11.2.2 Land Use	
		11.2.3 Site Characterization and Risk Assessment Results	
		11.2.4 Interim Removal Actions	11-2
	11.3	Remedial Action Objectives	11-2
	11.4	Remedial Actions	11-2
		11.4.1 Remedy Implementation	11-2
		11.4.2 Remedy Operation and Maintenance	11-2
		11.4.3 Progress Since the 2010 Five-Year Review	11-2
	11.5	Technical Assessment	11-3
	11.6	Issues, Recommendations, and Follow-up Actions	11-3
	11.7	Statement of Protectiveness	11-3
	11.8	References	11-3
12	Onera	able Unit 12 (Site 3)	12-1
12	12.1	Site History and Background	
	12.2	Site Characterization	
		12.2.1 Physical Characteristics	
		12.2.2 Land Use	
		12.2.3 Site Characterization and Risk Assessment Results	
	12.3	Remedial Action Objectives	
	12.4	Remedial Actions	
		12.4.1 Remedy Implementation	
		12.4.2 Remedy Operation and Maintenance	
		12.4.3 Progress since the 2010 Five-Year Review	
	12.5	Technical Assessment	
	12.6	Issues, Recommendations, and Follow-up Actions	
	12.7	Statement of Protectiveness	
	12.8	References	
13	Opera	able Unit 13 (Site 63)	12.1
13	13.1	Site History and Background	
	13.2	Site Characterization	
	15.2	13.2.1 Physical Characteristics	
		13.2.2 Land Use	
		13.2.3 Site Characterization and Risk Assessment Results	
	13.3	Remedial Action Objectives	
	13.4	Remedial Actions	
	15.4	13.4.1 Remedy Implementation	
		13.4.2 Remedy Operation and Maintenance	
		13.4.3 Progress Since the 2010 Five-Year Review	
	13.5	Technical Assessment	
	13.6	Issues, Recommendations, and Follow-up Actions	
	13.7	Statement of Protectiveness	
	13.8	References	

14	Opera	able Unit 14 (Site 69)	14-1
	14.1	Site History and Background	14-1
	14.2	Site Characterization	14-1
		14.2.1 Physical Characteristics	14-1
		14.2.2 Land Use	14-1
		14.2.3 Site Characterization and Risk Assessment Results	14-1
	14.3	Remedial Action Objectives	14-2
	14.4	Remedial Actions	14-2
		14.4.1 Remedy Implementation	14-3
		14.4.2 Remedy Operation and Maintenance	14-3
		14.4.3 Progress Since the 2010 Five-Year Review	
	14.5	Technical Assessment	
	14.6	Issues, Recommendations, and Follow-up Actions	
	14.7	Statement of Protectiveness	
	14.8	References	
15	Opera	able Unit 16 (Sites 89 and 93)	15-1
	15.1	Site History and Background	15-1
	15.2	Site Characterization	15-1
		15.2.1 Physical Characteristics	15-1
		15.2.2 Land Use	
		15.2.3 Site Characterization and Risk Assessment Results	15-2
		15.2.4 Interim Removal Actions	15-3
	15.3	Remedial Action Objectives	15-4
	15.4	Remedial Actions	
		15.4.1 Remedy Implementation	15-5
		15.4.2 Remedy Operation and Maintenance	
		15.4.3 Progress Since the 2010 Five-Year Review	
	15.5	Technical Assessment	
	15.6	Issues, Recommendations, and Follow-up Actions	
	15.7	Statement of Protectiveness	
	15.8	Reference	
16	Opera	able Unit 19 (Site 84)	16-1
	16.1	Site History and Background	16-1
	16.2	Site Characterization	16-1
		16.2.1 Physical Characteristics	16-1
		16.2.2 Land Use	16-1
		16.2.3 Site Characterization and Risk Assessment Results	16-2
		16.2.4 Interim Removal Actions	
	16.3	Remedial Action Objectives	
	16.4	Remedial Actions	16-3
		16.4.1 Remedy Implementation	
		16.4.2 Remedy Operation and Maintenance	
		16.4.3 Progress Since the 2010 Five-Year Review	
	16.5	Technical Assessment	
	16.6	Issues, Recommendations, and Follow-up Actions	
	16.7	Statement of Protectiveness	
	16.8	References	
17	Opera	able Unit 20 (Site 86)	17-1
•	-	Site History and Background	

	17.2	Site Characterization	17-1
		17.2.1 Physical Characteristics	17-1
		17.2.2 Land Use	17-1
		17.2.3 Site Characterization and Risk Assessment Results	17-1
		17.2.4 Interim Removal Actions	17-2
	17.3	Remedial Action Objectives	17-2
	17.4	Remedial Actions	17-2
		17.4.1 Remedy Implementation	17-3
		17.4.2 Remedy Operation and Maintenance	17-3
		17.4.3 Progress Since the 2010 Five-Year Review	17-3
	17.5	Technical Assessment	17-3
	17.6	Issues, Recommendations, and Follow-up Actions	17-4
	17.7	Statement of Protectiveness	17-4
	17.8	References	17-4
18	0,000	able Unit 21 (Site 73)	10.1
10	18.1	Site History and Background	
	18.2	Site Characterization	
	10.2	18.2.1 Physical Characteristics	
		18.2.2 Land Use	
		18.2.3 Site Characterization and Risk Assessment Results	
		18.2.4 Interim Removal Actions	
	18.3	Remedial Action Objectives	
	18.4	Remedial Actions	
	18.5	Remedy Implementation	
	10.5	18.5.1 Remedy Operation and Maintenance	
		18.5.2 Progress since the 2010 Five-Year Review	
	18.6	Technical Assessment	
	18.7	Issues, Recommendations, and Follow-up Actions	
	18.8	Statement of Protectiveness	
	18.9	References	
19	-	able Unit 23 (Site 49)	
	19.1	Site History and Background	
	19.2	Site Characterization	
		19.2.1 Physical Characteristics	
		19.2.2 Land Use	
		19.2.3 Site Characterization and Risk Assessment Results	
	19.3	Remedial Action Objectives	
	19.4	Remedial Actions	
		19.4.1 Remedy Implementation	
		19.4.2 Remedy Operation and Maintenance	
		19.4.3 Progress Since the 2010 Five-Year Review	
	19.5	Technical Assessment	
	19.6	Issues, Recommendations, and Follow-up Actions	
	19.7	Statement of Protectiveness	
	10 Q	Peferences	10.2

Appendixes

- A LUC Inspection Report
- B Site Inspection Checklist
- C Laboratory Results for 1,4-dioxane Sampling

Tables

- ES-1 Five-Year Review Summary Table
- 1-1 Summary of Sites by Operable Unit
- 2-1 Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2014)
- 3-1 Cleanup Levels for OU 1 (Sites 21, 24, and 78)
- 3-2 OU 1 Remedial Action Summary and Expected Outcomes
- 3-3 OU 1 Land Use Control Summary
- 3-4 2010 FYR Recommendations/Follow-up Actions
- 3-5 Supplemental Investigations Since the 2010 FYR
- 3-6 Maximum Concentration of Select COCs Detected During the RI and SGI (Site 78 North)
- 3-7 Maximum Concentration of Select COCs Detected During the RI and SGI (Site 78 South)
- 3-8 OU 1 Recommendations and Follow-up Actions
- 4-1 Cleanup Levels for OU 2 (Sites 6 and 82)
- 4-2 OU 2 Remedial Action Summary and Expected Outcomes
- 4-3 Site 82 Groundwater Treatment Plant Effluent Levels
- 4-4 OU 2 Land Use Control Summary
- 4-5 2010 FYR Recommendations/Follow-up Actions
- 4-6 Supplemental Investigations Since the 2010 FYR
- 4-7 OU2 Recommendations and Follow-up Actions
- 5-1 Cleanup Levels for OU 4 (Sites 41 and 74)
- 5-2 OU 4 Remedial Action Summary and Expected Outcomes
- 5-3 OU 4 Land Use Control Summary
- 5-4 2010 FYR OU 4 Recommendations/Follow-up Actions
- 6-1 Groundwater Cleanup Levels for OU 5 (Site 2)
- 6-2 Soil Cleanup Levels for OU 5 (Site 2)
- 6-3 OU 5 Remedial Action Summary and Expected Outcomes
- 6-4 OU 5 Land Use Control Summary
- 6-5 2010 FYR OU 5 Recommendations/Follow-up Actions
- 6-6 OU5 Recommendations and Follow-up Actions
- 7-1 Cleanup Levels for OU 6 (Site 36)
- 7-2 OU 6 Remedial Action Summary and Expected Outcomes
- 7-3 OU 6 Land Use Control Summary
- 7-4 2010 FYR OU 6 Recommendations/Follow-up Actions
- 7-5 Select COC Concentrations in the UCH Aguifer Site 36
- 7-6 Site 36 Summary of NAIPs December 2013
- 7-7 OU 6 Recommendations and Follow-up Actions
- 8-1 Cleanup Levels for OU 7 (Sites 1 and 28)
- 8-2 OU 7 Remedial Action Summary and Expected Outcomes
- 8-3 OU 7 Land Use Control Summary
- 8-4 2010 FYR OU 7 Recommendations/Follow-up Actions

ES120414012346RAL XV

9-1	OU 8 Remedial Action Summary	y and Expected Outcomes

- 9-2 OU 8 Land Use Control Summary
- 9-3 2010 FYR OU 8 Recommendations/Follow-up Actions
- 10-1 Cleanup Levels for OU 10 (Site 35)
- 10-2 OU 10 Remedial Action Summary and Expected Outcomes
- 10-3 OU 10 Land Use Control Summary
- 10-4 2010 FYR OU 10 Recommendations/Follow-up Actions
- 10-5 Site 35 Summary of NAIPs December 2013
- 10-6 OU 10 Recommendations and Follow-up Actions
- 11-1 Cleanup Levels for OU 11 (Site 80)
- 11-2 OU 11 Remedial Action Summary and Expected Outcomes
- 11-3 OU 11 Land Use Control Summary
- 11-4 2010 FYR OU 11 Recommendations/Follow-up Actions
- 11-5 OU 11 Surface and Subsurface Soil Screening, Industrial Scenario Risk Ratio, Maximum Detected Concentration
- 12-1 Groundwater Cleanup Levels for OU 12 (Site 3)
- 12-2 Soil Cleanup Levels for OU 12 (Site 3)
- 12-3 OU 12 Remedial Action Summary and Expected Outcomes
- 12-4 OU 12 Land Use Control Summary
- 12-5 2010 FYR OU 12 Recommendations/Follow-up Actions
- 13-1 OU 13 Remedial Action Summary and Expected Outcomes
- 13-2 OU 13 Land Use Control Summary
- 13-3 2010 FYR OU 13 Recommendations/Follow-up Actions
- 14-1 Cleanup Levels for OU 14 (Site 69)
- 14-2 OU 14 Remedial Action Summary and Expected Outcomes
- 14-3 OU 14 Land Use Control Summary
- 14-4 2010 FYR OU 14 Recommendations/Follow-up Actions
- 15-1 Cleanup Levels for OU 16 (Site 89)
- 15-2 Cleanup Levels for OU 16 (Site 93)
- 15-3 OU 16 Remedial Action Summary and Expected Outcomes
- 15-4 OU 16 (Site 89) Land Use Control Summary
- 15-5 OU 16 (Site 93) Land Use Control Summary
- 15-6 2010 FYR OU 16 (Site 93) Recommendations/Follow-up Actions
- 15-7 Select COC Concentrations at Site 89
- 15-8 Site 89 Summary of NAIPs June 2014
- 15-9 Site 93 Summary of NAIPs December 2013
- 16-1 Cleanup Levels for OU 19 (Site 84)
- 16-2 OU 19 Remedial Action Summary and Expected Outcomes
- 16-3 OU 19 Land Use Control Summary
- 16-4 2010 FYR OU 19 Recommendations/Follow-up Actions
- 17-1 Cleanup Levels for OU 20 (Site 86)
- 17-2 OU 20 Remedial Action Summary and Expected Outcomes
- 17-3 OU 20 Land Use Control Summary
- 17-4 OU 20 Recommendations and Follow-up Actions
- 18-1 Cleanup Levels for OU 21 (Site 73)
- 18-2 OU 21 Remedial Action Summary and Expected Outcomes
- 18-3 OU 21 Land Use Control Summary

XVI ES120414012346RAL

- 18-4 2010 FYR OU 21 Recommendations/Follow-up Actions
- 18-5 Site 73 Summary of NAIPs March 2014
- 18-6 OU 21 Recommendations and Follow-up Actions
- 19-1 Cleanup Levels for OU 23 (Site 49)
- 19-2 OU 23 Remedial Action Summary and Expected Outcomes
- 19-3 OU 23 Land Use Control Summary

Figures

- 1-1 Base Location Map
- 1-2 OU Location Map
- 3-1 OU 1 (Site 21, 24, 78, and SWMU 574)
- 3-2 Cumulative VOC Removal Site 78 North
- 3-3 Cumulative VOC Removal Site 78 South
- 3-4 Site 78 Conceptual Site Model
- 3-5 Supplemental Groundwater Investigation BTEX Plume Maps Site 78 North
- 3-6 Supplemental Groundwater Investigation Chlorinated VOC Plumes Site 78 North
- 3-7 Supplemental Groundwater Investigation BTEX Plume Maps Site 78 South
- 3-8 Supplemental Groundwater Investigation Chlorinated VOC Plume Maps Site 78 South
- 4-1 OU 2 (Sites 6, 9, and 82) and UXO-22
- 4-2 Cumulative VOC Removal Site 82 Treatment Plant
- 4-3 Site 6 Conceptual Site Model
- 4-4 Site 82 Conceptual Site Model
- 4-5 Supplemental Investigation Site 6 Chlorobenzene in Groundwater
- 4-6 Supplemental Investigation Site 6 Chlorinated Ethenes in Groundwater
- 4-7 Supplemental Investigation Site 82 Chlorinated Ethenes in Groundwater
- 4-8 Supplemental Investigation Site 82 1,1,2,2 Tetrachloroethane in Groundwater
- 5-1 OU 4 (Site 41)
- 5-2 OU 4 (Site 74)
- 6-1 OU 5 (Site 2)
- 7-1 OU 6 (Sites 36, 43, 44, and 54)
- 7-2 Site 36 Conceptual Site Model
- 7-3 COC Trends in UCH Aguifer Site 36
- 7-4 Site 36 Approximate Extent of TCE Exceedances in the Surficial Aquifer
- 7-5 Site 36 Approximate Extent of VC Exceedances in the Surficial Aquifer
- 7-6 Site 36 Approximate Extent of TCE Exceedances in the UCH Aquifer
- 7-7 Site 36 Approximate Extent of VC Exceedances in the UCH Aquifer
- 8-1 OU 7 (Site 1 and 28)
- 9-1 OU 8 (Site 16)
- 10-1 OU 10 (Site 35)
- 10-2 Site 35 Conceptual Site Model
- 10-3 Site 35 Approximate Extent of TCE Exceedances in the Surficial Aguifer
- 10-4 Site 35 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer
- 10-5 Site 35 Approximate Extent of VC Exceedances in the Surficial Aquifer
- 10-6 Site 35 Approximate Extent of TCE Exceedances in the UCH Aquifer
- 10-7 Site 35 Approximate Extent of cis-1,2-DCE Exceedances in the UCH Aquifer
- 10-8 Site 35 Approximate Extent of VC Exceedances in the UCH Aquifer
- 10-9 Site 35 Approximate Extent of Benzene Exceedances in the Surficial Aquifer

ES120414012346RAL XVII

- 10-10 Site 35 Approximate Extent of Benzene Exceedances in the UCH Aquifer
- 11-1 OU 11 (Sites 7 and 80)
- 12-1 OU 12 (Site 3)
- 12-2 Site 3 Conceptual Site Model
- 12-3 COC Trends IR03-MW02
- 12-4 Benzo(a)anthracene Trends
- 13-1 OU 13 (Site 63)
- 14-1 OU 14 (Site 69)
- 14-2 Site 69 Conceptual Site Model
- 15-1 OU 16 (Sites 89 and 93)
- 15-2 Site 89 Conceptual Site Model
- 15-3 Site 93 Conceptual Site Model
- 15-4 HAS Operating Parameters
- 15-5 VAS Operating Parameters
- 15-6 Site 89 Approximate Extent of 1,1,2,2-PCA Exceedances in the Surficial Aquifer
- 15-7 Site 89 Approximate Extent of TCE Exceedances in the Surficial Aquifer
- 15-8 Site 89 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer
- 15-9 Site 89 Approximate Extent of VC Exceedances in the Surficial Aquifer
- 15-10 Site 89 Approximate Extent of TCE Exceedances in the UCH Aquifer
- 15-11 Site 89 Approximate Extent of 1,2-cis-DCE Exceedances in the UCH Aquifer
- 15-12 Site 89 Approximate Extent of VC Exceedances in the UCH Aguifer
- 15-13 TCE Concentrations in IR89-MW89 Cluster
- 15-14 VC Concentrations in IR89-MW89 Cluster
- 15-15 TCE Concentrations in IR89-MW93 Cluster
- 15-16 VC Concentrations in IR89-MW93 Cluster
- 15-17 ORP Trends: In-wall Performance Monitoring Wells
- 15-18 ORP Trends: Downgradient Performance Monitoring Wells
- 15-19 Site 93 Approximate Extent of TCE Exceedances in the Surficial Aquifer
- 15-20 Site 93 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer
- 15-21 Site 93 Approximate Extent of VC Exceedances in the Surficial Aguifer
- 16-1 OU 19 (Site 84)
- 17-1 OU 20 (Site 86)
- 17-2 Site 86 Conceptual Site Model
- 18-1 OU 21 (Site 73)
- 18-2 Site 73 Conceptual Site Model
- 18-3 Site 73 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer
- 18-4 Site 73 Approximate Extent of VC Exceedances in the Surficial Aquifer
- 18-5 Site 73 Approximate Extent of TCE Exceedances in the UCH Aquifer
- 18-6 Site 73 Approximate Extent of cis-1,2-DCE Exceedances in the UCH Aquifer
- 18-7 Site 73 Approximate Extent of VC Exceedances in the UCH Aquifer
- 18-8 Site 73 Approximate Extent of Benzene Exceedances in the Surficial Aquifer
- 18-9 Site 73 Approximate Extent of Benzene Exceedances in the UCH Aquifer
- 19-1 OU 23 (Site 49)
- 19-2 Site 49 Conceptual Site Model

XVIII ES120414012346RAL

Acronyms and Abbreviations

3DMe three-dimensional microemulsion

AFFF aqueous film forming foam
amsl above mean sea level
AOC area of concern
AR administrative record

ARAR applicable or relevant and appropriate requirement

AS air sparging

AST aboveground storage tank

bgs below ground surface

BTEX benzene, toluene, ethylbenzene, and xylenes

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act

cfm cubic feet per minute
CFR Code of Federal Regulation

CLEAN Comprehensive Long-term Environmental Action – Navy

COC chemicals of concern

COPC chemical of potential concern

CSM conceptual site model

CVOC chlorinated volatile organic compound

DCA dichloroethane
DCE dichloroethene

DDD dichlorodiphenyldichloroethane DDT dichlorodiphenyltrichloroethane

DHC Dehalocoiccoides

DNAPL dense non-aqueous phase liquid

DO dissolved oxygen
DoD Department of Defense
DPT direct-push technology

DRMO Defense Reutilization and Marketing Office

ECP Environmental Condition of Property
EPH extractable petroleum hydrocarbons

ERA ecological risk assessment

ERD enhanced reductive dechlorination

ERH electrical resistive heating

ESD Explanation of Significant Differences

ESI Expanded Site Inspection

ESRI Expanded Supplemental Remedial Investigation

EVO emulsified vegetable oil

FFA Federal Facilities Agreement

FS Feasibility Study
FY Fiscal Year

FYR Five-Year Review

GIS geographic information system
HDD horizontal directionally drilled
HHRA human health risk assessment

ES120414012346RAL XIX

HHRS human health risk screening
HPCA Hadnot Point Construction Area

HPFF Hadnot Point Fuel Farm
HPIA Hadnot Point Industrial Area
HRC hydrogen release compound

IAS Initial Assessment Study IRA interim remedial action

IRACR Interim Remedial Action Completion Report

IRP Installation Restoration Program

ISCO in-situ chemical oxidation

L liter

LCH lower Castle Hayne

LNAPL light non-aqueous phase liquid

LTM Long-term Monitoring

LUC land use control

LUCIP Land Use Control Implementation

μg/L
 MC
 MCH
 MCAS
 MCB
 Microgram per liter
 munitions constituents
 middle Castle Hayne
 Marine Corps Air Station
 Marine Corps Base

MCL Maximum Contaminant Level

MD munitions debris

MEC munitions and explosives of concern

MEE methane, ethane, ethene MIP membrane interface probe

mL milliliter

MMRP Military Munitions Response Program MNA Monitored Natural Attenuation

MPPEH material potentially presenting an explosive hazard MSCC maximum soil contamination concentrations

NA natural attenuation

NACIP Navy Assessment and Control of Installation Pollutants

NAIP natural attenuation indicator parameter NAVFAC Naval Facilities Engineering Command

Navy Department of the Navy

NC North Carolina

NCAC North Carolina Administrative Code

NCDENR North Carolina Department of Environment and Natural Resources

NCGWQS North Carolina groundwater quality standard

NCP National Oil and Hazardous Substance Pollution Contingency Plan

NCSWQS North Carolina surface water quality standard

ND not detected

NFA no further action

NPL National Priorities List

NRP Notice of Residual Petroleum

NSW Nutrient Sensitive Waters

NTCRA non-time-critical removal action

XX ES120414012346RAL

O&G oil and grease

O&M operation and maintenance
ORC oxygen release compound
ORP oxidation-reduction potential

OU Operable Unit
OWS oil/water separator

PA Preliminary Assessment

PAH polycyclic aromatic hydrocarbon

PCA tetrachloroethane

PCB polychlorinated biphenyl
PDB passive diffusion bag
PCE tetrachloroethene

PFC perfluorinated compound
POL petroleum, oil, and lubricants
PRB permeable reactive barrier

PSG passive soil gas

psi pounds per square inch

RA remedial action

RAB Restoration Advisory Board

RACR remedial action completion report

RAO remedial action objective RBC risk-based concentration

RCRA Resource Conservation and Recovery Act

RD remedial design

RI remedial investigation

ROD Record of Decision

RSL regional screening level

SARA Superfund Amendments and Reauthorization Act

scfm standard cubic feet per minute

SGI Supplemental Groundwater Investigation

SI Site Inspection
SSL soil screening level
SVE soil vapor extraction

SVOC semivolatile organic compound SWMU solid waste management unit

TCA trichloroethane
TCE trichloroethylene

TCRA time-critical removal action

TDS total dissolved solids
TOC total organic carbon
TSS total suspended solids

TSI-DC Terra Systems Incorporated DC Bioaugmentation Culture

UCH upper Castle Hayne

USEPA United States Environmental Protection Agency

UST underground storage tank

UU/UE unlimited use and unrestricted exposure

VC vinyl chloride VI vapor intrusion

ES120414012346RAL XXI

VIMS vapor intrusion mitigation system VOC Volatile Organic Compound

VPH volatile petroleum hydrocarbons

ZVI zero-valent iron

XXII ES120414012346RAL

Introduction

This document presents the fourth Five-Year Review (FYR) for Marine Corps Base (MCB) Camp Lejeune and Marine Corps Air Station (MCAS) New River, North Carolina (NC), prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The previous FYR was completed in 2010. This FYR evaluates the remedial actions (RAs) that have been implemented within 17 Operable Units (OUs) at MCB Camp Lejeune or MCAS New River for which there is an Interim or Final Record of Decision (ROD) or for which interim RAs have been conducted.

This document has been prepared for submittal to Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, MCB Camp Lejeune and MCAS New River, United States Environmental Protection Agency (USEPA) Region 4, and the North Carolina Department of Environment and Natural Resources (NCDENR).

1.1 Objectives and Approach

The objective of this FYR is to evaluate the RAs at MCB Camp Lejeune and MCAS New River and determine whether they remain protective of human health and the environment in accordance with the requirements outlined in the ROD for each OU. The protectiveness of the remedies was evaluated through reviews of technical reports, site visits and inspections, and community involvement activities. In addition, this FYR identifies issues, if any, that may be preventing a particular remedy from functioning as designed or as appropriate, or that could impact the protection of human health and the environment.

The Department of the Navy (Navy) has prepared this FYR pursuant to CERCLA 121 and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). CERCLA Section 121 states the following: "If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews."

USEPA interpreted this requirement further in the NCP as stated in 40 Code of Federal Regulations (CFR) 300.430 (f)(4)(ii): "If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action."

The statutory review process was initiated based on the RA at OU 1 in September 1993. The first FYR was completed in 1999 (Baker, 1999). The second and third FYRs were completed in 2005 (Baker, 2005) and 2010 (CH2M HILL, 2010). The current FYR is required because hazardous contaminants remain at concentrations exceeding criteria that allow for unlimited use and unrestricted exposure (UU/UE) at each of the 17 OUs addressed in this document.

1.2 Installation Background

MCB Camp Lejeune and MCAS New River, also referred to as Camp Lejeune or the Base, comprise approximately 236 square miles of land in Onslow County, NC, near the southern boundary of the City of Jacksonville (**Figure 1-1**). The Base is bordered by the Atlantic Ocean to the east and bisected by the New River, which flows into the Atlantic Ocean in a southeasterly direction.

Commissioned in 1942, the Base currently provide military training operations and maintains combat-ready warfighters for deployment and humanitarian missions abroad. The Base provides housing, training facilities, and logistical support for Fleet Marine Force Units and other assigned units.

ES120414012346RAL 1-1

1.2.1 Regional Water Use

Potable water is provided to the Base and surrounding area by water supply wells that pump groundwater from the deeper Castle Hayne aquifer. There are currently active water supply wells on Base that rely on groundwater as the supply source. The supply wells are included in the Base's annual wellhead monitoring program to ensure compliance with drinking water standards. Regionally, in southeastern NC, the Castle Hayne aquifer may be used as a potable source of domestic water supply and for watering lawns or filling swimming pools.

1.2.2 Environmental Restoration Program

The Base has been actively engaged with environmental investigations and remediation programs since 1981, beginning with the Navy Assessment and Control of Installation Pollutants (NACIP) Program. The Initial Assessment Study (IAS) (WAR, 1983) was the first investigation of potentially hazardous sites at the Base conducted under the NACIP. The IAS identified areas of concern (AOC) that might cause threats to human health and the environment as a result of past storage, handling, and disposal of hazardous materials.

The Navy's Installation Restoration Program (IRP) was initiated in 1986, following enactment of the Superfund Amendments and Reauthorization Act (SARA) legislation. The IRP, which was implemented to follow the requirements of SARA, replaced NACIP. The Base was placed on the CERCLA National Priorities List (NPL) on October 4, 1989 (54 Federal Register 41015, October 4, 1989). Following the listing, a Federal Facilities Agreement (FFA) between USEPA Region 4, NCDENR, and the Navy was signed in February 1991.

As part of the requirements established under CERCLA, an administrative record (AR) file has been established for MCB Camp Lejeune. The AR is a compilation of all documents the Department of Defense (DoD) uses to select an RA or removal action for a site. The AR is available online at: http://go.usa.gov/Dy5T. Internet access is available to the public at the Onslow Public Library.

1.3 Operable Units and Sites

MCB Camp Lejeune and MCAS New River currently have 26 OUs, of which 17 were identified for this FYR (**Table 1-1**). Each OU comprises one or more sites that were grouped on the basis of proximity, common waste types, and/or common operational activities (**Figure 1-2**).

1.4 Report Organization

The FYR for MCB Camp Lejeune and MCAS New River consists of an Executive Summary and 19 sections, organized as follows:

- **Executive Summary** Summarizes the FYR process conducted at MCB Camp Lejeune and MCAS New River and findings. A summary table of the OUs, associated sites, site descriptions, documents reviewed, basis for action, site status, remedy components, recommendations and follow-up actions, protectiveness determinations, and FYR status is provided as **Table ES-1**.
- Section 1 Introduces the FYR and its purpose, and provides the background of the Base and the OUs.
- **Section 2** Describes the FYR process.
- Sections 3 through 19 Evaluates each of the 17 OUs included in this FYR. Discussion elements for each OU include the site history and background, site chronology, and site characterization; description of RAs (remedy implementation and remedy operation and maintenance [O&M]); progress since the last FYR; technical assessment; issues, recommendations and follow-up actions; and statement of protectiveness. References, figures, tables, and a photograph log are provided within each section, as applicable.

Appendixes are provided at the end of the document.

1-2 ES120414012346RAL

1.5 References

Baker. 1999. Five-year Review. Marine Corps Base, Camp Lejeune, North Carolina. August.

Baker. 2005. Five Year Review, Marine Corps Base Camp Lejeune Jacksonville, North Carolina. January.

CH2M HILL. 2010. Five-year Review. Marine Corps Base Camp Lejeune, North Carolina. August.

Water and Air Research, Inc. (WAR). 1983. Initial Assessment Study for MCB Camp Lejeune, North Carolina.

ES120414012346RAL 1-3

TABLE 1-1
Summary of Sites by Operable Unit
2015 Five-Year Review

OU	SITE NO.	Site Description	Primary Reason for OU Selection	Inclusion in the FYR
1	21	Transformer Storage Lot 140		Included
	24	Industrial Area Fly Ash Dump	Geographic location of sites.	Included
	78	Hadnot Point Industrial Area		Included
	6	Storage Lots 201 and 203		Included
2	9	Fire Fighting Training Pit at Piney Green Road	Geographic location of sites.	Not Included - NFA
	82	Piney Green Road VOC Area		Included
3	48	MCAS Mercury Dump	Similar characteristic of suspected waste (mercury).	Not Included - NFA
4	41	Camp Geiger Dump near Former Trailer Park	Similar characteristic of suspected waste (chemical	Included
4	74	Mess Hall Grease Dump Area	warfare materials).	Included
5	2	Former Nursery/Day Care Center	Similar characteristics of material handled at site (pesticides).	Included
	36	Camp Geiger Dump Area Near Sewage Treatment Plant		Included
C	43	Agan Street Dump	Similar characteristics of material disposed (POL, waste	Included
6	44	Jones Street Dump	oils, solvents) and contaminants detected (metals, VOCs,O&G). Geographic location of sites.	Included
	54	Crash Crew Fire Training Burn Pit	O&G). Geographic location of sites.	Included
	1	French Creek Liquids Disposal Area		Included
7	28	Hadnot Point Burn Dump	Geographic location of sites. Similar characteristics of	Included
	30	Sneads Ferry Road Fuel Tank Sludge Area	suspected waste (O&G, POL, and metals).	Not Included - NFA
8	16	Former Montford Point Burn Dump	Geographic location of site.	Included
9	65	Engineer Area Dump	Geographic location of site.	Not Included - NFA
10	35	Camp Geiger Fuel Farm	Accelerated cleanup necessary to abate impacts to Brinson Creek.	Included
11	7	Tarrawa Terrace Dump	Coographic location of sites	Not Included - NFA
11	80	Paradise Point Golf Course Maintenance Area	Geographic location of sites.	Included
12	3	Old Creosote Plant	Isolated site with unique waste source.	Included
13	63	Verona Loop Dump	Isolated site with unique waste source.	Included
14	69	Rifle Range Chemical Dump	Isolated site with unique waste source.	Included
15	88	Base Dry Cleaners	Similar characteristic of suspected waste (dry cleaning solvent).	Not Included - ROD not complete

TABLE 1-1
Summary of Sites by Operable Unit
2015 Five-Year Review

Camp Lejeune,	North	Carolina
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ou	SITE NO.	Site Description	Primary Reason for OU Selection	Inclusion in the FYR
16	89	Former DRMO	Geographic location of sites and adjacent surface water	Included
16	93	Building TC-942	body. Similar characteristic of suspected waste (solvents).	Included
	90	Building BB-9	Former UST sites with similar contamination detected in	Not Included - NFA
17	91	Building BB-51	groundwater.	Not Included - NFA
	92	Building BB-46	-groundwater.	Not Included - NFA
18	94	PCX Service Station	Geographic location of site, within Site 78, and similar contaminants in adjacent shallow groundwater plume. Former UST site.	Not Included - NFA
19	84	Building 45	Isolated site with similar waste (PCBs, POL).	Included
20	86	Tank Area AS419-AS421 at MCAS	Site 86 was originally included under OU 6. Separate OU created due to increasing levels of VOCs.	Included
21	73	Courthouse Bay Liquids Disposal Area	Similar characteristic of suspected wastes (POL, solvents).	Included
22	96	Building 1817 UST	Transferred to IRP from RCRA based on chlorinated VOC plume identified.	Not Included - ROD not complete
23	49	MCAS Suspected Minor Dump	Isolated site with chlorinated VOCs in groundwater.	Included
24	UXO-06	Fortified Beach Assault Area (ASR #2.65)	Isolated site with potential MEC.	Not Included - ROD not complete
25	UXO-19	M-4, Rifle Grenade Range (ASR# 2.104) K-22 Practice Hand Grenade Course (ASR# 2.111) M115 Hand Grenade Course (ASR# 2.168)	Isolated site with potential MEC. Not Included - RC complete	

Notes:

DRMO - Defense Reutilization and Marketing Office

O&G - oil and grease

OU - Operable Unit

MCAS - Marine Corps Air Station

MEC- munitions and explosives of concern

NFA - No Further Action

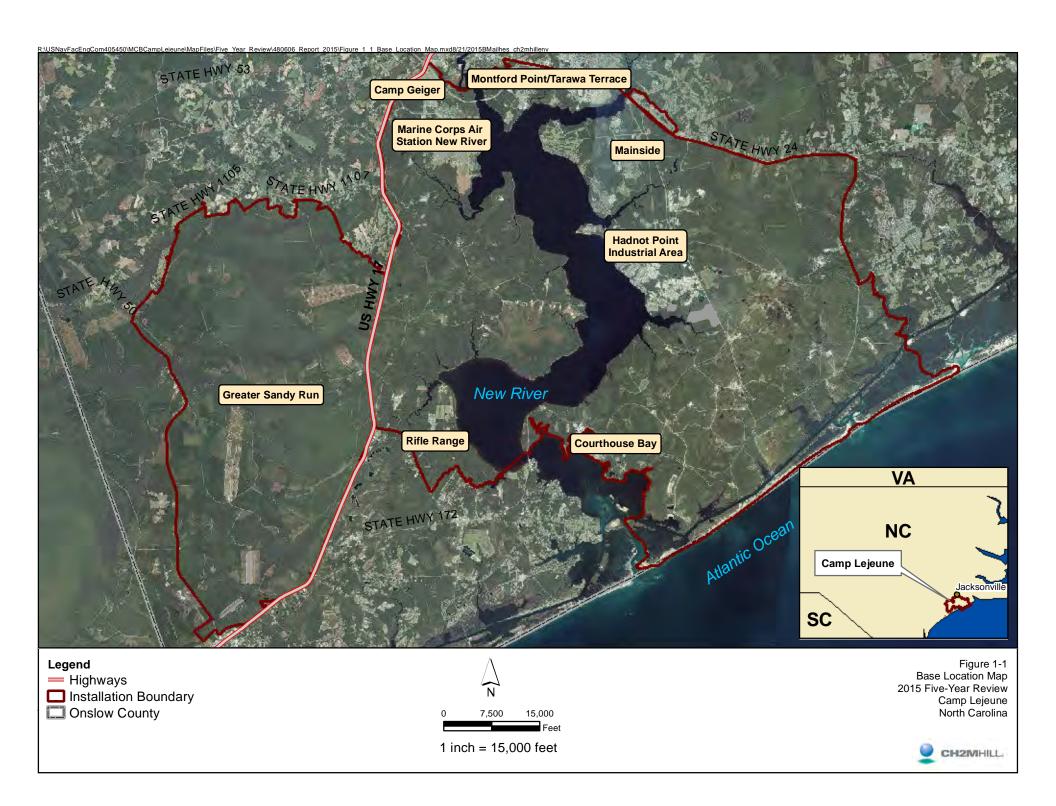
PCBs - polychlorinated biphenyls

POL - petroleum, oil, lubricants

RCRA - Resource Conservation and Recovery Act

UST - underground storage tank

VOCs - volatile organic compounds





Five-Year Review Process

The FYR for MCB Camp Lejeune and MCAS New River was conducted in accordance with the *Comprehensive Five-Year Review Guidance* (USEPA, 2001) and supplements (USEPA, 2012a, 2012b), *Navy/Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Reviews* (Navy, 2011), the *Toolkit for Preparing Five-Year Reviews* (Navy, 2013), and the DoD *Defense Environmental Restoration Program (DERP) Management Manual* and 2014 Five-Year Review Procedures Update (DoD, 2012, 2014). Remedy protectiveness for the 17 OUs was evaluated through technical document reviews, site inspections, and community involvement activities as described in the following subsections.

2.1 Document Review

As summarized below, the FYR consisted of a review of site-specific documentation for each OU.

- ROD to identify the potential risks to human health and the environment, remedial action objectives (RAOs), the selected remedy, and applicable or relevant and appropriate requirements (ARARs).
- Remedial design (RD) to evaluate the design components for the remedy, as well as any monitoring requirements and land use control (LUC) elements and boundaries.
- Interim Remedial Action Completion Reports (IRACRs) (if applicable) to confirm that the remedies are operational and functional in accordance with the RAOs and RD.
- Follow-up monitoring reports to assess remedy performance and continued protection of human health and the environment.

2.1.1 Risk Review

Changes in the toxicity and USEPA regional screening levels (RSLs) for chemicals of concern (COCs) were reviewed to identify potential concerns in relation to the previous human health risk assessments (HHRA) (**Table 2-1**).

Although there have been some procedural changes to HHRA methodologies, including how the chemicals of potential concern (COPCs) that are quantitatively evaluated in the risk assessment are identified, the statistical method to estimate exposure point concentrations, the exposure parameter values, and the method to address the chemicals with mutagenic mode of action, none of these changes would affect the protectiveness of the remedies.

2.1.2 Emerging Contaminants

1,4-dioxane

Since the 2010 FYR, an RSL was established for emerging contaminant 1,4-dioxane. Sampling for 1,4-dioxane was completed at Sites 35, 69, 73, 89, and 93 in 2002. The presence of chemicals such as 1,1,1-trichloroethane (TCA), 1,1-dichloroethane (DCA), and 1,1-dichloroethene (DCE) in groundwater can indicate the potential presence of 1,4-dioxane. 1,4-dioxane was used to stabilize 1,1,1-TCA. 1,1-DCA is a degradation byproduct of 1,1,1-TCA and 1,1-DCE is a byproduct of producing 1,1,1-TCA, thus their presence can indicate the historical presence of 1,1,1-TCA, and 1,4-dioxane. Historical data were evaluated for relevant OUs and recommendations are provided in each section as applicable.

Perfluorinated compounds

Certain perfluorinated compounds (PFCs) have been identified as emerging contaminants by the Navy (Navy, 2015). PFCs have been used in a variety of industrial and military applications such as aqueous film forming foam (AFFF), which may have been used to put out fires at former firefighting training areas or crashes at Air Stations. A review of historical site use was conducted at all FYR sites to identify sites with the potential for the presence PFCs. Recommendations are provided in each section as applicable.

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2.2 Site Inspections

MCB Camp Lejeune Environmental Management Division conducts quarterly inspections to verify that LUCs such as fencing and signs are still in place and to verify that there are no issues with the LUC implementation process. The annual reports from 2009 to 2014 and most recent LUC inspection checklists are provided in **Appendix A**.

CH2M HILL conducted an inspection of the FYR sites on March 27 and 28, 2014. The Partnering Team, consisting of representatives of NAVFAC Mid-Atlantic, MCB Camp Lejeune Environmental Management Division, USEPA Region 4, and NCDENR, conducted a site visit of key FYR sites on May 29, 2014. Any issues concerning the protectiveness of remedies were noted and are discussed in individual OU sections.

2.3 Community Involvement

The Marine Corps has taken a proactive approach to site cleanup by reaching out to the local community through the Restoration Advisory Board (RAB). The RAB was created in 1995 and is made up of members of the community, civic and business organizations, and civilian employees. The RAB meets quarterly, and provides tours, onsite demonstrations of new technologies, and informative talks.

The AR and Community Involvement Plan can be obtained from the IRP web site: http://go.usa.gov/Dy5T.

The Base also hosts a public web site where information is posted to enhance information exchange between the Base and community:

http://www.lejeune.marines.mil/OfficesStaff/EnvironmentalMgmt/RestorationAdvisoryBoard.aspx.

Internet access is available to the public at the Onslow County Library.

Activities to involve the community in the FYR process were initiated with a notification published in early May 2014 in local newspapers (*The Globe* and *The Jacksonville Daily News*) that announced that the FYR process was occurring at MCB Camp Lejeune and MCAS New River. The community was also informed of the initiation of the FYR at a RAB meeting on May 28, 2014. When the FYR has been finalized, a notice will be sent to these newspapers indicating the results of the review and that the report is available to the public.

2.4 Interviews

Concurrent with the FYR, an update to the Community Involvement Plan was initiated. Questionnaires were provided at the RAB during the November 2014 meeting and emailed out to the RAB members following the meeting. Specific questions related to the FYR were included in the questionnaire. In-person interviews were conducted with community members in December 2014 and the results will be documented in the Community Involvement Plan in 2015. In general, the overall impression of IRP and RAs is positive.

2.5 Next Five-Year Review

The next FYR is due to be finalized in 2020.

2.6 References

Department of Defense (DoD). 2012. *Defense Environmental Restoration Program (DERP) Management Manual Number 4715.20.* March 9.

DoD. 2014. Five-Year Review Procedures – Update to DoD Manual (DoDM) 4715.20, "Defense Environmental Restoration Program (DERP) Management" March 2, 2012. June 2.

Navy. 2011. Navy/Marine Corps Policy for Conducting comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews. June.

Navy. 2013. Toolkit for Preparing Five-Year Reviews. December.

Navy. 2014. Perfluorinated Compounds (PFCs) Interim Guidance/Frequently Asked Questions (FAQs). January.

USEPA. 2001. Comprehensive Five-Year Review Guidance.

2-2 ES120414012346RAL

USEPA. 2012a. Assessing Protectiveness at Sites for Vapor Intrusion: Supplement to the Comprehensive Five-Year Review Guidance. November.

USEPA. 2012b. Clarifying the Use of Protectiveness Determinations for CERCLA Five-Year Reviews. September.

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TABLE 2-1

Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2014)

2015 Five-Year Review

									Ingest	ion Exposure									Inhalation	Exposure ^a				
						Oral R	teference Dose				Ca	ncer Slope Fact			lı	nhalation I	Reference Cor		(RfC)		Inha	lation Unit Ri	sk (IUR)	
					 		(mg/kg-day)					(mg/kg-da	y) 		1		(mg/m³)	1				(ug/m ³) ⁻¹		
Operable Unit	Site Number	Chemical Group	Analyte	CAS	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk
OU 1	Sites 21, 24, and 78		1,1,2,2-Tetrachloroethane	79-34-5	4.0E-03	Р	2.0E-02	I	Decrease	2.0E-01	1	2.0E-01	I							5.8E-05	I	5.8E-05	С	
		VOC VOC	1,1-Dichloroethene 1,2,4-Trimethylbenzene	75-35-4 95-63-6	5.0E-02		5.0E-02	1							2.0E-01 7.0E-03	l P	2.0E-01 7.0E-03	l P						
		VOC	1,2-Dichloroethane	107-06-2	2.0E-02	Р	6.0E-03	Х	Increase	9.1E-02	1	9.1E-02	1		2.4E+00	A	7.0E-03	P	Increase	2.6E-05	1	2.6E-05	1	
		VOC	1,2-Dichloroethene (Total) ^c	540-59-0	2.0E-02	1	2.0E-02	1							6.0E-02	P			Decrease					
		VOC VOC	Benzene Ethylbenzene	71-43-2 100-41-4	4.0E-03 1.0E-01		4.0E-03 1.0E-01			5.5E-02 1.1E-02	C	5.5E-02 1.1E-02	C		3.0E-02 1.0E+00		3.0E-02 1.0E+00			7.8E-06 2.5E-06	C	7.8E-06 2.5E-06	c	
		VOC	Tetrachloroethene	127-18-4	1.0E-02	- 1	6.0E-03	1	Increase	5.4E-01	С	2.1E-03	I	Decrease	2.7E-01	Α	4.0E-02	1	Increase	5.9E-06	C	2.6E-07	i	Decrease
		VOC VOC	Toluene Trichloroethene	108-88-3 79-01-6	8.0E-02		8.0E-02 5.0E-04		 Increase	 5.9E-03	 C	 4.6E-02	1	 Increase	5.0E+00		5.0E+00 2.0E-03		 Increase	2.0E-06	 C	 4.1E-06		 Increase
		VOC	Vinyl chloride	75-01-4	3.0E-03	1	3.0E-03	i		7.2E-01	ī	7.2E-01	i		1.0E-01	1	1.0E-01	i		4.4E-06	ı	4.4E-06	i	
		VOC	Xylenes (total)	1330-20-7	2.0E-01	ı	2.0E-01	1		7.25.01	 E	 7.2F.01	 E		1.0E-01	1	1.0E-01	I		1 15 04	 C	1 15 04	 C	
		SVOC SVOC	Benzo(a)anthracene Benzo(a)pyrene	56-55-3 50-32-8						7.3E-01 7.3E+00	I	7.3E-01 7.3E+00	I							1.1E-04 1.1E-03	C	1.1E-04 1.1E-03	c	
		SVOC	Benzo(b)fluoranthene	205-99-2						7.3E-01	E	7.3E-01	E							1.1E-04	С	1.1E-04	С	
		SVOC SVOC	Benzo(k)fluoranthene Chrysene	207-08-9 218-01-9						7.3E-02 7.3E-03	E E	7.3E-02 7.3E-03	E E							1.1E-04 1.1E-05	C	1.1E-04 1.1E-05	C C	
		SVOC	Dibenz(a,h)anthracene	53-70-3						7.3E+00	E	7.3E+00	E							1.2E-03	c	1.2E-03	c	
		SVOC SVOC	Indeno(1,2,3-cd)pyrene Naphthalene	193-39-5 91-20-3	 2.0E-02		 2.0E-02	 I		7.3E-01	E	7.3E-01	E		 3.0E-03		 3.0E-03			1.1E-04 3.4E-05	С	1.1E-04 3.4E-05	C C	
		PCB	Total PCBs ^d		2.0E-05	i	2.0E-05	;		2.0E+00		2.0E+00	S		3.0L=03		3.0L-03 			5.7E-04	ı	5.7E-04	S	
		Pesticide	4,4-DDD	72-54-8						2.4E-01	1	2.4E-01	1							6.9E-05	С	6.9E-05	С	
		Pesticide Pesticide	4,4-DDE 4,4-DDT	72-55-9 50-29-3	 5.0E-04		 5.0E-04	 I		3.4E-01 3.4E-01		3.4E-01 3.4E-01	1							9.7E-05 9.7E-05	С	9.7E-05 9.7E-05	С	
			Chlordane (total)	12789-03-6	5.0E-04	i	5.0E-04	i		3.5E-01	i	3.5E-01	i		7.0E-04	1	7.0E-04	1		1.0E-04	i	1.0E-04	i	
		Pesticide	Dieldrin	60-57-1	5.0E-05	1	5.0E-05	!		1.6E+01	!	1.6E+01	1		4 55 05	6			Decrease	4.6E-03	1	4.6E-03	!	
		Metal Metal	Arsenic Barium	7440-38-2 7440-39-3	3.0E-04 2.0E-01	i	3.0E-04 2.0E-01	i		1.5E+00 		1.5E+00 			1.5E-05 5.0E-04	C H	1.5E-05 5.0E-04	C H		4.3E-03 		4.3E-03 		
		Metal	Beryllium	7440-41-7	2.0E-03	1	2.0E-03	1							2.0E-05	1	2.0E-05	1		2.4E-03	1	2.4E-03	1	
		Metal Metal	Cadmium Chromium ^e	7440-43-9 18540-29-9	5.0E-04 3.0E-03		5.0E-04 3.0E-03			5.0E-01		 5.0E-01			1.0E-05 1.0E-04	A	1.0E-05 1.0E-04	A		1.8E-03 8.4E-02		1.8E-03 8.4E-02	S	
		Metal	Manganese	7439-96-5	1.4E-01	i	1.4E-01	i		J.UL-01 					5.0E-05	i	5.0E-05	i		0.4L-02 		0.4L=02 		
011.2	C'1 C . O 1 . O .	Metal	Vanadium	7440-62-2	7.0E-05	P	5.0E-03	S	Decrease						1.0E-04	Α	1.0E-04	Α						
OU 2	Sites 6, 9, and 82	VOC VOC	1,1,2,2-Tetrachloroethane 1,1-Dichloroethene	79-34-5 75-35-4	4.0E-03 5.0E-02	P I	2.0E-02 5.0E-02	i	Decrease 	2.0E-01 		2.0E-01 			2.0E-01	1	2.0E-01	 I		5.8E-05 		5.8E-05 		
		VOC	1,2-Dichloroethane	107-06-2	2.0E-02	Р	6.0E-03	х	Increase	9.1E-02	- 1	9.1E-02	- 1		2.4E+00	Α	7.0E-03	Р	Increase	2.6E-05	- 1	2.6E-05	- 1	
		VOC VOC	1,2-Dichloroethene (Total) ^c 1,4-Dichlorobenzene	540-59-0 106-46-7	2.0E-02 7.0E-02	I A	2.0E-02 7.0E-02	I A		 5.4E-03	 C	 5.4E-03	 C		6.0E-02 8.0E-01	P	 8.0E-01		Decrease	 1.1E-05		 1.1E-05		
		VOC	Benzene	71-43-2	4.0E-03	ı	4.0E-03	ı		5.5E-02	ı	5.5E-02	ı		3.0E-02	i	3.0E-02	i		7.8E-06	ı	7.8E-06	ı	
		VOC	Chlorobenzene	108-90-7	2.0E-02	1	2.0E-02	!							5.0E-02	P	5.0E-02	P						
		VOC VOC	Ethylbenzene Tetrachloroethene	100-41-4 127-18-4	1.0E-01 1.0E-02	i	1.0E-01 6.0E-03		 Increase	1.1E-02 5.4E-01	C C	1.1E-02 2.1E-03	C	 Decrease	1.0E+00 2.7E-01	A	1.0E+00 4.0E-02		 Increase	2.5E-06 5.9E-06	C	2.5E-06 2.6E-07	ı	Decrease
		VOC	Trichloroethene	79-01-6			5.0E-04	1	Increase	5.9E-03	С	4.6E-02	1	Increase			2.0E-03	1	Increase	2.0E-06	С	4.1E-06	1	Increase
		VOC PCB	Vinyl chloride Total PCBs ^d	75-01-4	3.0E-03 2.0E-05		3.0E-03 2.0E-05			7.2E-01 2.0E+00		7.2E-01 2.0E+00	l s		1.0E-01		1.0E-01	'		4.4E-06 5.7E-04		4.4E-06 5.7E-04	l s	
			4,4-DDT	50-29-3	5.0E-04	i	5.0E-04	i		3.4E-01	i	3.4E-01	ı							9.7E-05	i	9.7E-04	١	
		Metal	Arsenic	7440-38-2	3.0E-04	1	3.0E-04	1		1.5E+00	- 1	1.5E+00	- 1		1.5E-05	С	1.5E-05	С		4.3E-03	- 1	4.3E-03	1	
		Metal Metal	Barium Beryllium	7440-39-3 7440-41-7	2.0E-01 2.0E-03		2.0E-01 2.0E-03								5.0E-04 2.0E-05	I	5.0E-04 2.0E-05	H		2.4E-03	1	2.4E-03	1	
		Metal	Cadmium	7440-43-9	5.0E-04	1	5.0E-04	- 1							1.0E-05	Α	1.0E-05	Α		1.8E-03	ı	1.8E-03	- 1	
		Metal Metal	Chromium ^e Manganese	18540-29-9 7439-96-5	3.0E-03 1.4E-01	l J	3.0E-03 1.4E-01			5.0E-01 	J 	5.0E-01	J 		1.0E-04 5.0E-05		1.0E-04 5.0E-05			8.4E-02	I	8.4E-02	S 	
			Mercury	7439-96-5	1.4E-01 1.6E-04	C			Decrease						3.0E-03	i	3.0E-03	i						
OU 4	Sitos 41 and 74		Vanadium	7440-62-2	7.0E-05	P	5.0E-03	S	Decrease	1 55,00		1 55,00			1.0E-04	A	1.0E-04	A		4.25.02		4.25.02		
OU 4	Sites 41 and 74	Metal Metal	Arsenic Beryllium	7440-38-2 7440-41-7	3.0E-04 2.0E-03		3.0E-04 2.0E-03			1.5E+00 		1.5E+00 			1.5E-05 2.0E-05	C	1.5E-05 2.0E-05	C		4.3E-03 2.4E-03		4.3E-03 2.4E-03		
		Metal	Cadmium ^f	7440-43-9	5.0E-04	ı	5.0E-04	I							1.0E-05	Α	1.0E-05	Α		1.8E-03	ı	1.8E-03	1	
		Metal	Cadmium ^g	7440-43-9	1.0E-03	I	1.0E-03	I							1.0E-05	Α	1.0E-05	Α		1.8E-03	ı	1.8E-03	1	
		Metal Metal	Chromium ^e Lead	18540-29-9 7439-92-1	3.0E-03 		3.0E-03	I		5.0E-01 	J 	5.0E-01	J 		1.0E-04 		1.0E-04	I		8.4E-02	I	8.4E-02	S 	
			Manganese ^{f,h}	7439-96-5		ı	1.4E-01	1							5.0E-05	1	5.0E-05	1						
		Metal	Manganese ^{g,h}	7439-96-5	1.4E-01	ı	1.4E-01	1							5.0E-05	1	5.0E-05	1						

									Ingest	ion Exposure								Inhalation Exposure a Inhalation Unit Risk (IUR)						
						Oral F	Reference Dose	e (RfDo)			Ca	ncer Slope Fac	tor (CSFo)			nhalation F	Reference Con	centration	(RfC)		Inha	lation Unit Ri	sk (IUR)	
	1					1	(mg/kg-day))	1			(mg/kg-da	y) ⁻¹	1			(mg/m ³)	1 1			1	(ug/m ³) ⁻¹	1	
Operable Unit	Site Number	Chemical Group	Analyte	CAS	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk
OU 5	Site 2	VOC	Ethylbenzene	100-41-4	1.0E-01	I	1.0E-01	I		1.1E-02	С	1.1E-02	С		1.0E+00	I	1.0E+00	I		2.5E-06	С	2.5E-06	С	
		VOC VOC	Toluene Trichloroethene	108-88-3 79-01-6	8.0E-02		8.0E-02 5.0E-04		 Increase	 5.9E-03	 C	 4.6E-02		 Increase	5.0E+00		5.0E+00 2.0E-03		 Increase	2.0E-06	 C	4.1E-06		 Increase
		VOC	Xylene (total)	1330-20-7	2.0E-01	1	2.0E-01	i							1.0E-01	- 1	1.0E-01	i						
		SVOC	Acenaphthene	83-32-9	6.0E-02	!	6.0E-02	!											Decrease					
		SVOC SVOC	2,4-Dimethyphenol 2-Methylnaphthalene	105-67-9 91-57-6	2.0E-02 4.0E-03	;	2.0E-02 4.0E-03																	
		SVOC	Naphthalene	91-20-3	2.0E-02	i	2.0E-02	i							3.0E-03	- 1	3.0E-03	1		3.4E-05	С	3.4E-05	С	
		SVOC	Phenol	108-95-2	3.0E-01	I	3.0E-01	I							2.0E-01	С	2.0E-01	С						
		Pesticide Pesticide	4,4-DDD 4,4-DDE	72-54-8 72-55-9						2.4E-01 3.4E-01		2.4E-01 3.4E-01								6.9E-05 9.7E-05	C C	6.9E-05 9.7E-05	C C	
		Pesticide	4,4-DDT	50-29-3	5.0E-04	ī	5.0E-04	1		3.4E-01	i	3.4E-01	i							9.7E-05	ı	9.7E-05	ı	
		Pesticide	Chlordane (total)	12789-03-6	5.0E-04	I .	5.0E-04	1		3.5E-01	1	3.5E-01	1		7.0E-04	- 1	7.0E-04	I		1.0E-04	1	1.0E-04	1	
		Pesticide Pesticide	Dieldrin Heptachlor	60-57-1 76-44-8	5.0E-05 5.0E-04		5.0E-05 5.0E-04			1.6E+01 4.5E+00		1.6E+01 4.5E+00							Decrease 	4.6E-03 1.3E-03		4.6E-03 1.3E-03		
		Metal	Arsenic	7440-38-2	3.0E-04	i	3.0E-04	i		1.5E+00	i	1.5E+00	i		1.5E-05	С	1.5E-05	С		4.3E-03	i	4.3E-03	i	
		Metal	Barium	7440-39-3	2.0E-01	I	2.0E-01	- 1							5.0E-04	Н	5.0E-04	Н						
		Metal Metal	Beryllium Lead	7440-41-7 7439-92-1	2.0E-03	1	2.0E-03	1							2.0E-05	1	2.0E-05	1		2.4E-03	I 	2.4E-03	I 	
		Metal	Vanadium	7440-62-2	7.0E-05	P	5.0E-03	S	Decrease						1.0E-04	A	1.0E-04	A						
OU 6	Sites 36, 43, 44, and 54	VOC	1,1,2,2-Tetrachloroethane	79-34-5	4.0E-03	Р	2.0E-02	I	Decrease	2.0E-01	- 1	2.0E-01	ı							5.8E-05	- 1	5.8E-05	С	
		VOC	1,1-Dichloroethene	75-35-4	5.0E-02	I	5.0E-02	- 1							2.0E-01	1	2.0E-01	1						
		VOC VOC	1,2-Dichloroethene (Total) ^c Benzene	540-59-0 71-43-2	2.0E-02 4.0E-03		2.0E-02 4.0E-03			 5.5E-02		5.5E-02	 I		6.0E-02 3.0E-02	P I	3.0E-02		Decrease	7.8E-06	 I	7.8E-06	1	
		VOC	Tetrachloroethene	127-18-4	1.0E-02	i	6.0E-03	i	Increase	5.4E-01	c	2.1E-03	l i	Decrease	2.7E-01	A	4.0E-02	i	Increase	5.9E-06	c	2.6E-07	i	Decrease
		VOC	Trichloroethene	79-01-6			5.0E-04	- 1	Increase	5.9E-03	С	4.6E-02	1	Increase			2.0E-03	1	Increase	2.0E-06	С	4.1E-06	- 1	Increase
		VOC Metal	Vinyl Chloride Arsenic	75-01-4 7440-38-2	3.0E-03 3.0E-04		3.0E-03 3.0E-04			7.2E-01 1.5E+00	1	7.2E-01 1.5E+00			1.0E-01 1.5E-05	l C	1.0E-01 1.5E-05	l C		4.4E-06 4.3E-03	!	4.4E-06 4.3E-03	1	
		Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P		1.5L+00 		1.3L+00 			1.3L-03 					4.31-03		4.31-03		
		Metal	Lead	7439-92-1																				
011.7	Citor 1 and 20	Metal VOC	Mercury Trichleresthese	7439-97-6	1.6E-04	С	 E OE O4		Decrease	 E 0E 03	 C	4.65.03		 Ingrass	3.0E-04	I	3.0E-04			 2.0F.06		4.15.06		 Increase
OU 7	Sites 1 and 28	Metal	Trichloroethene Antimony	79-01-6 7440-36-0	4.0E-04	1	5.0E-04 4.0E-04		Increase 	5.9E-03 		4.6E-02 		Increase 			2.0E-03 		Increase 	2.0E-06	C 	4.1E-06 		Increase
		Metal	Arsenic	7440-38-2	3.0E-04	ı	3.0E-04	- 1		1.5E+00	1	1.5E+00	1		1.5E-05	С	1.5E-05	С		4.3E-03	1	4.3E-03	- 1	
		Metal	Copper	7440-50-8	4.0E-02	Н	4.0E-02	Н											Increase					
		Metal Metal	Lead Manganese ^{f,h}	7439-92-1 7439-96-5	 1.4E-01		1.4E-01								5.0E-05		 5.0E-05							
		Metal	Manganese ^{g,h}	7439-96-5	1.4E-01	;	1.4E-01	;							5.0E-05	;	5.0E-05							
		Metal	Zinc	7440-66-6	3.0E-01	i	3.0E-01	i																
OU 8	Site 16	VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I		5.5E-02	1	5.5E-02	1		3.0E-02		3.0E-02	- 1		7.8E-06	I	7.8E-06	1	
		SVOC Pesticide	Benzo(a)pyrene Dieldrin	50-32-8 60-57-1	5.0E-05		5.0E-05			7.3E+00 1.6E+01		7.3E+00 1.6E+01							 Decrease	1.1E-03 4.6E-03	С	1.1E-03 4.6E-03	C	
		PCB	Aroclor 1254	11097-69-1	2.0E-05	i	2.0E-05	i		2.0E+00	i	2.0E+00	S							5.7E-04	i	5.7E-04	S	
		PCB	Aroclor 1260	11096-82-5						2.0E+00	!	2.0E+00	S							5.7E-04	1	5.7E-04	S	
		Metal Metal	Arsenic Beryllium	7440-38-2 7440-41-7	3.0E-04 2.0E-03		3.0E-04 2.0E-03			1.5E+00	'	1.5E+00	<u> </u>		1.5E-05 2.0E-05	C	1.5E-05 2.0E-05	C		4.3E-03 2.4E-03		4.3E-03 2.4E-03		
		Metal	Lead	7439-92-1																				
		Metal	Manganese ^h	7439-96-5	1.4E-01	I	1.4E-01	- I							5.0E-05	1	5.0E-05	l l						
OU 10	Site 35	VOC VOC	1,1,2,2-Tetrachloroethane	79-34-5	4.0E-03	P	2.0E-02	!	Decrease 	2.0E-01	!	2.0E-01	!		 2 OF O2	1	 2 OF O2			5.8E-05	 	5.8E-05	С	
		VOC	Benzene cis-1,2-Dichloroethene	71-43-2 156-59-2	4.0E-03 1.0E-02	P	4.0E-03 2.0E-03	l i	Increase	5.5E-02 		5.5E-02 			3.0E-02 		3.0E-02 			7.8E-06 		7.8E-06 		
		VOC	Tetrachloroethene	127-18-4	1.0E-02	ı	6.0E-03	i	Increase	5.4E-01	С	2.1E-03	1	Decrease	2.7E-01	Α	4.0E-02	1	Increase	5.9E-06	С	2.6E-07	- 1	Decrease
		VOC	Trichloroethene	79-01-6	 2 OE O2		5.0E-04	!	Increase	5.9E-03	С	4.6E-02	1	Increase	 1 0E 01		2.0E-03		Increase	2.0E-06	С	4.1E-06	1	Increase
		VOC Metal	Vinyl chloride Antimony	75-01-4 7440-36-0	3.0E-03 4.0E-04		3.0E-03 4.0E-04			7.2E-01 		7.2E-01 	<u>'</u>		1.0E-01 		1.0E-01 			4.4E-06		4.4E-06 		
		Metal	Arsenic	7440-38-2	3.0E-04	i	3.0E-04	i		1.5E+00	1	1.5E+00	1		1.5E-05	С	1.5E-05	С		4.3E-03	- 1	4.3E-03	- 1	
		Metal	Cadmium	7440-43-9	5.0E-04	l l	5.0E-04	- 1							1.0E-05	Α	1.0E-05	Α		1.8E-03	1	1.8E-03	I	
		Metal	Chromium ^e	18540-29-9	3.0E-03	! 	3.0E-03	!		5.0E-01	J	5.0E-01	J		1.0E-04	1	1.0E-04	I		8.4E-02	1	8.4E-02	S	
OU 11	Site 80	Metal Pesticide	Mercury ¹ 4,4-DDD	7439-97-6 72-54-8	3.0E-04		3.0E-04			 2.4E-01	 I	2.4E-01	 I		3.0E-05	C	3.0E-04	S	Decrease 	6.9E-05	 C	6.9E-05	 C	
3311	5.1.2 55	Pesticide	4,4-DDT	50-29-3	5.0E-04	ı	5.0E-04	1		3.4E-01	i	3.4E-01	i	-						9.7E-05	ī	9.7E-05	Ī	
			Aldrin	309-00-2	3.0E-05	I	3.0E-05	1		1.7E+01	!	1.7E+01	!							4.9E-03	1	4.9E-03	1	
		Pesticide Pesticide	Alpha-Chlordane Dieldrin	12789-03-6 60-57-1	5.0E-04 5.0E-05		5.0E-04 5.0E-05			3.5E-01 1.6E+01		3.5E-01 1.6E+01			7.0E-04	'	7.0E-04 		 Decrease	1.0E-04 4.6E-03		1.0E-04 4.6E-03		
			Gamma-Chlordane	5566-34-7	5.0E-04	i	5.0E-04	i		3.5E-01	i	3.5E-01	i		7.0E-04	1	7.0E-04	1		1.0E-04	i	1.0E-04	i	
			Arsenic	7440-38-2	3.0E-04	I	3.0E-04	- 1		1.5E+00	I	1.5E+00	- 1		1.5E-05	С	1.5E-05	С		4.3E-03	I	4.3E-03	- 1	

									Ingest	tion Exposure									Inhalation	Exposure ^a				
						Oral F	Reference Dos				Ca	ncer Slope Fac	tor (CSFo)		1	nhalation F	Reference Con	centration	(RfC)		Inha	alation Unit Ri	sk (IUR)	
-1		Į.		-		1	(mg/kg-day))	1		1	(mg/kg-da	ay) ⁻¹			1	(mg/m³)	1	-		1	(ug/m ³) ⁻¹		
Operable Unit	Site Number	Chemical Group	Analyte	CAS	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risi
OU 12	Site 3	VOC VOC	2-Methylnaphthalene Benzene	91-57-6 71-43-2	4.0E-03 4.0E-03	I	4.0E-03 4.0E-03	ı		 5.5E-02		 5.5E-02			 3.0E-02		 3.0E-02			 7.8E-06		 7.8E-06		
		VOC	Chloroform	67-66-3	1.0E-02	i	1.0E-02	i		3.1E-02	c	3.1E-02	c		9.8E-02	A	9.8E-02	A		2.3E-05	i	2.3E-05	i	
		VOC	Vinyl chloride	75-01-4	3.0E-03	!	3.0E-03	1		7.2E-01	1	7.2E-01	1		1.0E-01	1	1.0E-01	1		4.4E-06	1	4.4E-06	- 1	
		SVOC SVOC	2,4-Dimethylphenol 2-Methylphenol	105-67-9 95-48-7	2.0E-02 5.0E-02	i	2.0E-02 5.0E-02								6.0E-01	 C	6.0E-01	C						
		SVOC	Acenaphthene	83-32-9	6.0E-02	- 1	6.0E-02	1											Decrease					
		SVOC SVOC	Benzo(a)anthracene Benzo(a)pyrene	56-55-3 50-32-8						7.3E-01 7.3E+00	E	7.3E-01 7.3E+00	E							1.1E-04 1.1E-03	C C	1.1E-04 1.1E-03	C C	
		SVOC	Benzo(b)flouranthene	205-99-2						7.3E-01	E	7.3E-01	E							1.1E-04	c	1.1E-04	c	
		SVOC	Benzo(k)flouranthene	207-08-9	2.05.02					7.3E-02	E	7.3E-02	E							1.1E-04	С	1.1E-04	С	
		SVOC SVOC	Bis(2-ethylheyxl)phthalate Carbazole	117-81-7 86-74-8	2.0E-02 		2.0E-02 			1.4E-02 		1.4E-02 								2.4E-06 	C 	2.4E-06 	C 	
		SVOC	Chrysene	218-01-9						7.3E-03	E	7.3E-03	E							1.1E-05	С	1.1E-05	С	
		SVOC SVOC	Dibenzofuran Naphthalene	132-64-9 91-20-3	1.0E-03 2.0E-02	X	1.0E-03 2.0E-02	X							 3.0E-03		 3.0E-03			 3.4E-05	 C	 3.4E-05	 C	
		SVOC	Phenanthrene ^j	85-01-8	3.0E-01	;	3.0E-01	l ;							3.01-03	'	3.0L=03 		Decrease	3.4L-03		3.4L-03 		
		SVOC	Phenol	108-95-2	3.0E-01	1	3.0E-01	- 1							2.0E-01	С	2.0E-01	С						
		Metal Metal	Aluminum Iron	7429-90-5 7439-89-6	1.0E+00 7.0E-01	P	1.0E+00 7.0E-01	P P							5.0E-03	P	5.0E-03	Р						
OU 13	Site 63	Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P																
01114	Sito 60	Metal	Zinc 1,1,2,2-Tetrachloroethane	7440-66-6	3.0E-01 NA	I NA	3.0E-01	1	 NA	 NA	 NA	 2 OF O1		 NA	 NA	 NA			 NA	 NA	 N/A	 5.8E-05		 NA
OU 14	Site 69	VOC VOC	1,1,2,2-Tetrachioroethane	79-34-5 79-00-5	NA NA	NA NA	2.0E-02 4.0E-03	;	NA NA	NA NA	NA NA	2.0E-01 5.7E-02	;	NA NA	NA NA	NA NA	2.0E-04	X	NA NA	NA NA	NA NA	1.6E-05	C	NA NA
		VOC	1,2-Dichloroethane	107-06-2	NA	NA	6.0E-03	х	NA	NA	NA	9.1E-02	1	NA	NA	NA	7.0E-03	Р	NA	NA	NA	2.6E-05	- 1	NA
		VOC VOC	cis-1,2-Dichloroethene trans-1,2-Dichloroethene	156-59-2 156-60-5	NA NA	NA NA	2.0E-03 2.0E-02		NA NA	NA NA	NA NA			NA NA	NA NA	NA NA			NA NA	NA NA	NA NA			NA NA
		VOC	Trichloroethene	79-01-6	NA	NA	5.0E-04	i	NA NA	NA NA	NA	4.6E-02	1	NA NA	NA NA	NA	2.0E-03	ı	NA	NA	NA	4.1E-06	1	NA
		VOC	Vinyl chloride	75-01-4	NA	NA	3.0E-03	1	NA	NA	NA	7.2E-01	1	NA	NA	NA	1.0E-01	- 1	NA	NA	NA	4.4E-06	1	NA
		Pesticide Pesticide	Alpha-BHC Dieldrin	319-84-6 60-57-1	NA NA	NA NA	8.0E-03 5.0E-05	A	NA NA	NA NA	NA NA	6.3E+00 1.6E+01		NA NA	NA NA	NA NA			NA NA	NA NA	NA NA	1.8E-03 4.6E-03	1 :	NA NA
		Pesticide	Heptachlor epoxide	1024-57-3	NA	NA	1.3E-05	1	NA	NA	NA	9.1E+00	- 1	NA	NA	NA			NA	NA	NA	2.6E-03	- 1	NA
		PCB Metal	Aroclor 1260 Beryllium	11096-82-5 7440-41-7	NA NA	NA NA	2.0E-03		NA NA	NA NA	NA NA	2.0E+00	S 	NA NA	NA NA	NA NA	 2.0E-05		NA NA	NA NA	NA NA	5.7E-04 2.4E-03	S	NA NA
		Metal	Chromium ^e	18540-29-9	NA NA	NA NA	3.0E-03	l ;	NA NA	NA NA	NA NA	5.0E-01	j	NA NA	NA NA	NA NA	1.0E-04	;	NA	NA NA	NA NA	8.4E-02	S	NA NA
		Metal	Lead	7439-92-1	NA	NA			NA	NA	NA			NA	NA	NA			NA	NA	NA			NA
		Metal	Manganese h	7439-96-5	NA	NA	1.4E-01	I	NA	NA	NA			NA	NA	NA	5.0E-05	1	NA	NA	NA			NA
		Metal Metal	Thallium Vanadium	7440-28-0 7440-62-2	NA NA	NA NA	1.0E-05 5.0E-03	X S	NA NA	NA NA	NA NA			NA NA	NA NA	NA NA	1.0E-04	Α	NA NA	NA NA	NA NA			NA NA
		Metal	Zinc	7440-66-6	NA	NA	3.0E-01	ı	NA	NA	NA			NA	NA	NA			NA	NA	NA			NA
OU 16	Sites 89 and 93	VOC	1,1,2,2-Tetrachloroethane 1,1,2-Trichloroethane	79-34-5 79-00-5	4.0E-03 4.0E-03	P	2.0E-02 4.0E-03		Decrease	2.0E-01 5.7E-02		2.0E-01 5.7E-02					 2.0E-04	 X	 Increase	5.8E-05 1.6E-05		5.8E-05 1.6E-05	С	
		VOC	1,2-Dichloroethane	107-06-2	2.0E-02	P	6.0E-03	X	Increase	9.1E-02	i	9.1E-02	i		2.4E+00	Α	7.0E-03	P	Increase	2.6E-05	i	2.6E-05	i	
		VOC	1,2-Dichloroethene (Total) ^c	540-59-0	2.0E-02	ı	2.0E-02	- 1							6.0E-02	Р			Decrease					
		VOC VOC	cis-1,2-Dichloroethene Tetrachloroethene	156-59-2 127-18-4	1.0E-02 1.0E-02	P	2.0E-03 6.0E-03		Increase Increase	 5.4E-01	 C	 2.1E-03	 I	 Decrease	 2.7E-01	 A	 4.0E-02	1	 Increase	 5.9E-06	 C	 2.6E-07		 Decrease
		VOC	trans-1,2-Dichloroethene	156-60-5	2.0E-02	i	2.0E-02	i							6.0E-02	P			Decrease					
		VOC	Trichloroethene	79-01-6			5.0E-04	!	Increase	5.9E-03	C	4.6E-02	1	Increase			2.0E-03	1	Increase	2.0E-06	C	4.1E-06	1	Increase
		VOC Metal	Vinyl chloride Arsenic	75-01-4 7440-38-2	3.0E-03 3.0E-04	i	3.0E-03 3.0E-04			7.2E-01 1.5E+00		7.2E-01 1.5E+00			1.0E-01 1.5E-05	C	1.0E-01 1.5E-05	C		4.4E-06 4.3E-03		4.4E-06 4.3E-03		
		Metal	Lead	7439-92-1																				
01110	C:+- 0.4	Metal	Manganese h	7439-96-5	1.4E-01	ı	1.4E-01	1		7.25.00		7.25.00			5.0E-05	ı	5.0E-05	I		1.15.03				
OU 19	Site 84	SVOC SVOC	Benzo(a)pyrene 2-Methyl-4-chlorophenoxyacetic acid	50-32-8 94-74-6	5.0E-04	1	5.0E-04	 I		7.3E+00 		7.3E+00 								1.1E-03 	C 	1.1E-03 	C 	
		Pesticide	Heptachlor	76-44-8	5.0E-04	ı	5.0E-04	1		4.5E+00	1	4.5E+00	1							1.3E-03	1	1.3E-03	1	
		PCB	Aroclor 1260	11096-82-5	2 05 05		 2 OE OE			2.0E+00		2.0E+00	S							5.7E-04	1	5.7E-04	S	
		PCB Metal	Total PCBs ^a Antimony	7440-36-0	2.0E-05 4.0E-04		2.0E-05 4.0E-04			2.0E+00 		2.0E+00 	S 							5.7E-04 		5.7E-04 	S 	
		Metal	Arsenic	7440-38-2	3.0E-04	ı	3.0E-04	1		1.5E+00	I I	1.5E+00	1		1.5E-05	С	1.5E-05	С		4.3E-03	- 1	4.3E-03	- 1	
		Metal	Iron Manganoso h	7439-89-6		P	7.0E-01	P							 5 OE OE		 E OE OE							
		Metal Metal	Manganese " Thallium	7439-96-5 7440-28-0	1.4E-01 		1.4E-01 1.0E-05	X	 Increase						5.0E-05 		5.0E-05 							
OU 20	Site 86	VOC	Benzene	71-43-2	NA	NA	4.0E-03	I	NA	NA	NA	5.5E-02	I	NA	NA	NA	3.0E-02	I	NA	NA	NA	7.8E-06	I	NA
		VOC VOC	cis-1,2-Dichloroethene Tetrachloroethene	156-59-2 127-18-4	NA NA	NA NA	2.0E-03 6.0E-03		NA NA	NA NA	NA NA	 2.1E-03	1	NA NA	NA NA	NA NA	 4.0E-02	 I	NA NA	NA NA	NA NA	 2.6E-07	1	NA NA
		VOC	Trichloroethene	79-01-6	NA NA	NA NA	5.0E-04	i	NA NA	NA NA	NA NA	4.6E-02	i	NA NA	NA NA	NA NA	2.0E-03	i	NA NA	NA NA	NA NA	4.1E-06	i	NA NA
		VOC	Vinyl chloride	75-01-4	NA	NA	3.0E-03	1	NA	NA	NA	7.2E-01	1	NA	NA	NA	1.0E-01	I I	NA	NA	NA	4.4E-06	1	NA
		Metal	Chromium ^e	18540-29-9	NA	NA	3.0E-03		NA	NA	NA	5.0E-01	J	NA	NA	NA	1.0E-04	I	NA	NA	NA	8.4E-02	S	NA

TABLE 2-1

Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2014)

2015 Five-Year Review

Camp Lejeune, North Carolina

									Ingest	ion Exposure									Inhalation	Exposure ^a				
						Oral R	eference Dose	(RfDo)			Car	ncer Slope Fac	tor (CSFo)		li	nhalation R	eference Con	centration	(RfC)		Inha	lation Unit Ris	k (IUR)	
							(mg/kg-day)					(mg/kg-da	y) ⁻¹				(mg/m³)					(ug/m ³) ⁻¹		
Operable Unit	Site Number	Chemical Group	Analyte	CAS	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Hazard	Historical Value ^a	Source	Current Value ^b	Source	Impact on Estimated Risk
OU 21	Site 73	VOC	1,1-Dichloroethene	75-35-4	5.0E-02	I	5.0E-02	I							2.0E-01	I	2.0E-01	I						
		VOC	Benzene	71-43-2	4.0E-03	1	4.0E-03	- 1		5.5E-02	- 1	5.5E-02	- 1		3.0E-02	1	3.0E-02	- 1		7.8E-06	1	7.8E-06	- 1	
		VOC	cis-1,2-Dichloroethene	156-59-2	1.0E-02	Р	2.0E-03	- 1	Increase															
		VOC	Trichloroethene	79-01-6			5.0E-04	- 1	Increase	5.9E-03	С	4.6E-02	- 1	Increase			2.0E-03	- 1	Increase	2.0E-06	С	4.1E-06	- 1	Increase
		VOC	Vinyl chloride	75-01-4	3.0E-03	1	3.0E-03	- 1		7.2E-01	- 1	7.2E-01	- 1		1.0E-01	1	1.0E-01	- 1		4.4E-06	- 1	4.4E-06	- 1	
		Metal	Iron	7439-89-6	7.0E-01	Р	7.0E-01	P																
		Metal	Vanadium	7440-62-2	7.0E-05	Р	5.0E-03	S	Decrease						1.0E-04	Α	1.0E-04	Α						
OU 23	Site 49	VOC	1,1,2,2-Tetrachloroethane	79-34-5	NA	NA	2.0E-02	I	NA	NA	NA	2.0E-01	- 1	NA	NA	NA			NA	NA	NA	5.8E-05	С	NA
		VOC	1,1,2-Trichloroethane	79-00-5	NA	NA	4.0E-03	I	NA	NA	NA	5.7E-02	- 1	NA	NA	NA	2.0E-04	Х	NA	NA	NA	1.6E-05	- 1	NA
		VOC	1,2-Dichloroethane	107-06-2	NA	NA	6.0E-03	Х	NA	NA	NA	9.1E-02	ı	NA	NA	NA	7.0E-03	Р	NA	NA	NA	2.6E-05	- 1	NA
		VOC	Benzene	71-43-2	NA	NA	4.0E-03	I	NA	NA	NA	5.5E-02	- 1	NA	NA	NA	3.0E-02	- 1	NA	NA	NA	7.8E-06	- 1	NA
		VOC	Chloroform	67-66-3	NA	NA	1.0E-02	- 1	NA	NA	NA	3.1E-02	С	NA	NA	NA	9.8E-02	Α	NA	NA	NA	2.3E-05	- 1	NA
		VOC	cis-1,2-Dichloroethene	156-59-2	NA	NA	2.0E-03	ı	NA	NA	NA			NA	NA	NA			NA	NA	NA			NA
		VOC	Tetrachloroethene	127-18-4	NA	NA	6.0E-03	1	NA	NA	NA	2.1E-03	ı	NA	NA	NA	4.0E-02	ı	NA	NA	NA	2.6E-07	ı	NA
		VOC	trans-1,2-Dichloroethene	156-60-5	NA	NA	2.0E-02	!	NA	NA	NA			NA	NA	NA			NA	NA	NA			NA
		VOC	Trichloroethene	79-01-6	NA	NA	5.0E-04	!	NA	NA	NA	4.6E-02	!	NA	NA	NA	2.0E-03	!	NA	NA	NA	4.1E-06	!	NA
		VOC	Vinyl chloride	75-01-4	NA	NA	3.0E-03	1	NA	NA	NA	7.2E-01	ı	NA	NA	NA	1.0E-01		NA	NA	NA	4.4E-06	1	NA
		Metal	Aluminum	7429-90-5	NA	NA	1.0E+00	P	NA	NA	NA	1.55.00		NA	NA	NA	5.0E-03	۲ ۲	NA	NA	NA	4.25.03		NA NA
		Metal	Arsenic	7440-38-2	NA	NA	3.0E-04		NA	NA	NA	1.5E+00		NA	NA	NA	1.5E-05	C	NA	NA	NA	4.3E-03		NA
		Metal	Chromium ^e	18540-29-9	NA	NA	3.0E-03	- 1	NA	NA	NA	5.0E-01	J	NA	NA	NA	1.0E-04		NA	NA	NA	8.4E-02	S	NA
		Metal	Iron	7439-89-6	NA	NA	7.0E-01	P	NA	NA	NA			NA	NA	NA			NA	NA	NA			NA
		Metal	Vanadium	7440-62-2	NA	NA	5.0E-03	S	NA	NA	NA			NA	NA	NA	1.0E-04	Α	NA	NA	NA			NA

Notes:

Inhalation values listed for non-volatile compounds (e.g., metals) are only applicable to dust inhalation and would not be appropriate for groundwater

Source:

- a Historical toxicity factors are toxicity factors available when the last Five-Year Review report was prepared in August 2010. The historical factors were obtained from the May 2010 version of RSL table.
- ^b Current toxicity factors are presented in the May 2014 version of RSL table.
- ^c trans-1,2-Dichloroethene used as surrogate for total 1,2-dichloroethene for current toxicity factors.
- ^d Aroclor 1254 used as surrogate for total PCBs toxicity factors.
- ^e Toxicity factors for chromium VI used as surrogate for chromium.
- ^f The RfD₀ for cadmium, manganese, and current cadmium RfD₀ were used for evaluation in water in the risk assessment.
- ^g The RfD_o for cadmium, manganese, and current cadmium RfD_o were used for evaluation in soil/sediment in the risk assessment.
- ^h The RfD_o for manganese was modified to account for the background dietary intake through food consumption.
- ⁱ The toxicity factors for mercuric chloride used as surrogate for mercury.
- $^{\rm j}$ The toxicity factors for for anthracene used as surrogate for phenanthrene..
- A = Agency for Toxic Substances and Disease Registry
- C = California Environmental Protection Agency
- E = Environmental Criteria and Assessment Office
- H = Health Effects Assessment Summary Tables (HEAST)
- I = Integrated Risk Information System (IRIS)
- J = New Jersey Department of Environmental Protection (NJDEP)
- P = Provisional Peer-Reviewed Toxicity Value (PPRTV)
- S (Chromium) = For hexavalent chromium, IRIS shows an air unit risk of 1.2E-2 per (µg/m³). While the exact ratio of hexavalent to trivalent chromium in the data used to derive the IRIS air unit risk value is not known, it is likely that both hexavalent and trivalent chromium were present. The RSLs calculated using the IRIS air unit risk assume that the hexavalent to trivalent chromium ratio is 1:6.
- S (Mercury) = The IRIS RfC for mercury (elemental) is used as a surrogate for mercuric chloride (and other mercury salts).
- S (Vanadium) = Oral RfD toxicity value for vanadium in RSL table is derived from the IRIS oral RfD for vanadium pentoxide by factoring out the molecular weight of the oxide ion
- S (PCBs/Aroclors) = Aroclor 1016 is considered "lowest risk" and assigned appropriate toxicity values. All other Aroclors are assigned the high risk toxicity values.
- X = Appendix PPRTV Screen (See FAQ #27)

Acronyms:

-- chemical is listed on the table but no value is provided.

PCB - polychlorinated biphenyl

SVOC - semi-volatile organic compound VOC - volatile organic compound

mg/m³ - milligrams per cubic meter

ug/m³ - micrograms per cubic meter

CAS - chemical abstracts service

NA - Not applicable, the OU was not included in the 2010 FYR

Operable Unit 1 (Sites 21, 24, and 78)

3.1 Site History and Background

OU 1 is within the Hadnot Point Industrial Area (HPIA) on the Mainside of the Base (**Figure 1-2**). OU 1 consists of three sites (Sites 21, 24, and 78) that have been grouped together because of their proximity to one another.

Site 21 — Transformer Storage Lot 140 is comprised of approximately 10 acres in the northern portion of the HPIA (Figure 3-1). From 1950 to 1951, a pit in the northern portion of Site 21 was used as a drainage receptor for oil from transformers. Surface discharge of transformer oils was also reported. The quantity of oil disposal is unknown. The pit reportedly measured 25 to 30 feet long by 6 feet wide and 8 feet deep. In 1958, a pest control shop was moved from Building 712 (Site 2) to Building 1105, located in the southern portion of Site 21. From 1958 to 1977, Building 1105 was used for pesticide mixing and as a cleaning area for pesticide application equipment. Overland discharge of wastewater generated during cleaning operations was documented. The estimated quantity of wastewater discharged was approximately 350 gallons per week in 1977.

Site 24 — Industrial Area Fly Ash Dump covers approximately 100 acres in the southeastern portion of the HPIA (Figure 3-1). Site 24 was used for the disposal of fly ash, cinders, solvents, used paint stripping compounds, sewage sludge, and water treatment sludge from the late 1940s to 1980s. Sludge from the wastewater and sewage treatment plants were reportedly disposed at this site starting in the late 1940s. Construction debris was reportedly disposed at the site in the 1960s. During 1972 to 1979, fly ash cinders and used cleaning solvents were dumped on the ground surface. An estimated 31,500 tons of fly ash were disposed at the site and an estimated 45,000 gallons of stripping compounds was disposed over a 7-year period.

Site 78 — **HPIA** was constructed in the late 1930s, and covers approximately 590 acres (**Figure 3-1**). The HPIA consists of maintenance shops,

1983	•IAS (Site OU 1)
1984- 1987	*Confirmation Study (Site 21 & 24)
1984- 1992	 Interim RI/Interim FS/Interim PRAP/Interim ROD for Surficial Aquifer (Site 78)
1994	•RI/FS (Site 21 & 24)
1994	•PRAP and ROD (OU 1)
1995	•ESD addressing soil cleanup levels (Site 21 & 78)
1995- 2002	•RIP (Site 21)
1995- Present	•LTM (Site 78)
1996- 1997	•LTM (Site 24)
1997	Notice of Non-significant Changes (Site 78)
2000	Optimization Study (Site 78)
2001- 2002	•Natural Attenuation Evaluation (Site 78)
2001	•Remedy Complete (Site 24)
2003- 2005	 Oxygen Release Compound (ORC) and Hydrogen Release Compoun Pilot Study (Site 78)
2007- 2014	Basewide VI Evaluation (Site 78)
2009- 2010	•Hadnot Point Industrial Area Evaluation (Site 78)
2009- 2011	•Plume Delineation (Site 78)
2011	Confirmatory Sampling Investigation (SWMU 574)
2011- 2013	•Supplemental Groundwater Investigation (Site 78)
2012	Hadnot Point Construction Area Risk Evaluation Update (Site 78)
2012	Historical Metals Evaluation (Site 78)
2012- Present	•Pilot Studies (Site 78)
2013	•RCRA Facility Investigation (SWMU 574)

warehouses, painting shops, printing shops, auto body shops, and other small industrial facilities. Site 78 has two distinct areas that are referred to as Site 78 North and Site 78 South. Due to the industrial nature of the site, many spills and leaks have occurred over the years. Most of these spills and leaks have consisted of petroleum-related products and solvents from underground storage tanks (USTs) and drums. The Hadnot Point Fuel Farm (HPFF), located within the HPIA, is the source of petroleum-related groundwater contamination in the central area of the OU and is being addressed under the UST program.

ES120414012346RAL 3-1

3.2 Site Characterization

The findings from various investigations at OU 1 that are pertinent to the FYR are summarized in this section.

3.2.1 Physical Characteristics

- Surface Features Sites 21 and 78 are primarily developed and flat while Site 24 is developed in the northern portion of the site and is primarily wooded. Storm water runoff is conveyed primarily via man-made ditches and storm sewers to Beaver Dam Creek to the north, Cogdels Creek (and unnamed tributaries) to the south, and the New River to the west of the site.
- Geology and Hydrogeology The subsurface at OU 1 generally consists of Coastal Plain deposits comprising layers of sand, silt, and clay underlain by sand, fossils, and limestone beds. Groundwater flows southsouthwest, toward Cogdels Creek and the New River (Baker, 1994a). The surficial aquifer in the area of Site 78 extends to a depth of approximately 30 feet below ground surface (bgs) where the upper Castle Hayne (UCH) aquifer is encountered extending from 30 to 60 feet bgs. The middle Castle Hayne (MCH) aquifer is encountered from 60 to 125 feet bgs and the lower Castle Hayne (LCH) is encountered to approximately 150 feet bgs.

3.2.2 Land Use

- Current Land Use Sites 21 and 78 are primarily industrial areas. Site 21 is used for storage and Site 78 is
 made up of maintenance shops, warehouses, painting shops, printing shops, auto body shops, and other
 industrial facilities. The wooded area of Site 24 is used for military vehicle maneuvers.
- Future Land Use There are no anticipated changes in land use.

3.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 1 Remedial Investigation (RI; Baker, 1994a).

Site 21

- Pesticides and polychlorinated biphenyls (PCBs) were the primary contaminants detected in soils and sediment at Site 21. Volatile organic compounds (VOCs), particularly chlorinated volatile organic compounds (CVOCs) and fuel-related compounds (benzene, toluene, ethylbenzene, and xylenes [BTEX]), and metals were detected in groundwater in the northeastern portion of the site.
- An HHRA and an Ecological Risk Assessment (ERA) were completed for Site 21 as part of the RI. No unacceptable risks to human health from exposure to constituents in soil and groundwater were identified. Although site-wide soils did not pose any unacceptable risks, isolated areas with higher concentrations of PCBs exceeded industrial risk levels and were recommended for removal. Potential ecological risks were identified based on exposure to pesticides and PCBs in soil at Site 21 (Baker, 1994a).

Site 24

- Pesticides and metals were the primary contaminants detected in soil and shallow groundwater at Site 24.
 The pesticide heptachlor epoxide was retained as a COC because it exceeded the North Carolina Groundwater Quality Standard (NCGWQS) or Federal Maximum Contaminant Level (MCL) at the time of the ROD.
- A HHRA and ERA were completed for Site 24 as part of the RI (Baker, 1994a). The HHRA identified potential
 unacceptable risks for future child and adult residents from exposure to metals and VOCs in groundwater at
 OU 1, which included Site 24. Metals in soil presented a potential risk to ecological receptors.

Site 78

 Pesticides, PCBs, and semivolatile organic compounds (SVOCs) were the primary contaminants detected in soil, and CVOCs and BTEX were detected in surficial aquifer groundwater at Site 78.

3-2 ES120414012346RAL

An HHRA and ERA were completed for Site 78 as part of the RI. Potential unacceptable risks for future
residents were identified from exposure to metals and VOCs in surficial aquifer groundwater. Although sitewide soils did not pose any unacceptable risks, isolated areas with higher concentrations of PCBs exceeded
industrial risk levels and were recommended for removal. Potential unacceptable ecological risks were
identified from exposure to pesticides and PCBs in soil (Baker, 1994a).

3.2.4 Interim Removal Actions

An interim ROD to address surficial aquifer groundwater VOC contamination at Site 78 was signed on September 23, 1992 (Baker, 1992). The RAO was to prevent human consumption of contaminated groundwater by containing the contaminated groundwater in the surficial aquifer. The interim remedial action (IRA) for Site 78 included the following major components:

- Two groundwater extraction and treatment systems to prevent migration of VOC plumes in the surficial aquifer groundwater at Site 78 North and Site 78 South.
- LUCs to prevent exposure to groundwater.
- Long-term monitoring (LTM) to monitor the effectiveness of the IRA.

The treatment system began operation in 1994 and was expanded in 1996 in accordance with the final ROD. System details are discussed in Section 3.4.

3.3 Remedial Action Objectives

The final ROD addressing soil and groundwater at OU 1 was signed on September 15, 1994 (Baker, 1994b). The RAOs identified for OU 1 were:

- To prevent current or future exposure to the contaminated groundwater and contaminated soils.
- To remediate groundwater contamination for future potential use of the aquifer.
- To treat or remove contaminated soil from designated AOCs.

An Explanation of Significant Differences (ESD) was issued in 1995 to revise the cleanup level for PCBs to the Federal PCB action level for industrial sites (Baker, 1995). The cleanup levels for OU 1 are presented in **Table 3-1**.

3.4 Remedial Actions

The OU 1 RA components and expected outcomes are summarized in **Table 3-2**. The final RA for OU 1 included the following major components:

- Expanding the groundwater extraction and treatment system.
- LTM to monitor changes in groundwater COC extent at Sites 24 and 78 and to monitor the effectiveness of the treatment system. Groundwater contamination at Site 21 is being addressed under LTM for Site 78.
- Remove pesticide and PCB-contaminated soil from Sites 21 and 78 to industrial levels.
- LUC implementation to prevent exposure to COCs in soil and groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the surficial and Castle Hayne aguifers within 1,000 feet of the estimated impacted groundwater extent.
 - Maintain the integrity of any existing or future monitoring or treatment system at the site.
 - Restrict intrusive activities within the vicinity of the estimated impacted groundwater extent.
 - Prohibit non-industrial land use within the extent of the former soil removal at Sites 21 and 78, which
 includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day
 care facilities.

ES120414012346RAL 3-3

3.5 Remedy Implementation

Soil Removal

In 1995, approximately 650 tons of pesticide-contaminated soil and 161 tons of PCB-contaminated soil were excavated from Sites 21 and 78 to meet industrial criteria and disposed of offsite (OHM, 1996).

Groundwater Extraction and Treatment System

The Site 78 North and Site 78 South groundwater extraction and treatment systems began operation in 1994 and were expanded in 1995 to include the selected remedy in the Final ROD. Groundwater from the recovery wells and sumps is treated as follows:

- 1. Oil/Water Separator (OWS)
- 2. Flocculation Tank
- 3. Settling Tank
- 4. Sand Filter (in parallel)
- 5. Air Stripper
- 6. Bag Filters (in parallel)
- 7. Carbon Vessels (in series)
- 8. Effluent Holding Tank
- 9. Effluent (to sanitary sewer)

The system was initially designed with 15 recovery wells screened within the surficial and UCH aquifers (from 25 to 35 feet bgs); however, several were taken offline in 1996 based on low influent concentrations (USMC, 1997). Site 78 North consists of 7 recovery wells, of which 3 are currently operational, and Site 78 South consists of 8 recovery wells, of which 6 are currently operational (**Figure 3-1**).

Long-term Monitoring and Land Use Controls

LTM at Sites 78 and 24 was initiated in 1994 and 1996, respectively, and is ongoing at Site 78, as described in the following section. LUCs were implemented at OU 1 in 2001 and updated in 2002 (Baker, 2002). LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in Base Master Planning and Geographic Information System (GIS).

3.5.1 Remedy Operation and Maintenance

Groundwater Extraction and Treatment System

Daily and weekly treatment system inspections include: recording system totalizer readings and pressure readings on sand filters and carbon vessels, and inspecting health and safety equipment and other plant equipment. Routine maintenance consists of bag filter replacement, air compressor maintenance, air stripper maintenance, OWS and settling tank cleaning, and backwashing sand filters and carbon vessels. Monthly O&M reports are provided to the Partnering Team and are included as attachments to the annual LTM reports.

The Site 78 North plant currently treats water from three recovery wells: IR78-RW10, IR78-RW11, and IR78-RW12, that span the surficial and upper portion of the UCH aquifer shown on **Figure 3-1**. During 2013, the system treated an average of 163,000 gallons of groundwater per month, and with an average influent concentration of 61.3 micrograms per liter (μ g/L), approximately 0.11 pounds of VOCs were removed per month. This is consistent with the last 7 years, suggesting asymptotic conditions. Approximately 112.5 pounds of VOCs have been removed since the system began operation and 90 percent of the mass removal occurred by 2005 (**Figure 3-2**). The annual O&M cost for the Site 78 North treatment system is estimated at \$90,000 or approximately \$68,000 per pound of VOCs removed.

The Site 78 South plant currently treats water from six recovery wells: IR78-RW05, IR78-RW06, IR78-RW08, IR78-RW13, IR78-RW14, and IR78-RW15 that span the surficial and upper portion of the UCH aquifer, shown on **Figure 3-1**. During 2013, an average of 187,000 gallons of groundwater were treated per month, and with an average influent concentration of 64.4 μ g/L, approximately 0.12 pounds of VOCs were removed per month. Total

3-4 ES120414012346RAL

influent concentrations of VOCs and removal amounts were asymptotic from 2007 to June 2010, but increased from May 2010 to September 2012 due to system upgrades, lowering pump intakes, and the reactivation of IR78-RW15 (**Figure 3-3**). Since September 2012, VOC removal amounts have remained consistent with an average of 170,000 gallons of water treated and 0.1 pounds of VOCs removed per month, suggesting asymptotic conditions. The annual O&M cost for the Site 78 South treatment system is estimated at \$90,000 or approximately \$75,000 per pound of VOC removed.

Long-term Monitoring

In 1997, a notice of Non-Significant Change was submitted to the USEPA and NCDENR and included the following changes to the LTM protocol at OU 1: removal of heptachlor epoxide after 4 rounds of LTM below cleanup levels, removal of metals based on concentrations similar to background, and removal of total suspended solids (TSS), total dissolved solids (TDS), and oil and grease (O&G) because the analytical groups were not COCs (USMC, 1997). LTM at Site 24 was discontinued, effective January 1998, when four rounds of data indicated that pesticides did not exceed cleanup levels and metals were removed from the LTM program (USMC, 1998).

LTM at Site 78 initially consisted of collecting groundwater samples from 21 surficial, 2 UCH, and 2 MCH aquifer monitoring wells and 8 supply wells for VOCs. The LTM network has been updated and optimized to encompass the extent of contamination and reduce redundancies, and currently includes 34 surficial, 19 UCH, 18 MCH, and 4 LCH aquifer monitoring wells, 3 surficial recovery wells, and 7 UCH recovery wells. The supply wells are currently inactive and/or abandoned and are no longer included in the LTM well network. Groundwater samples are collected annually and are analyzed for VOCs. Groundwater samples collected from surficial aquifer monitoring wells are analyzed for metals every three years (CH2M HILL, 2013b).

The LTM protocol is continually evaluated for optimization opportunities. In 2013, the use of passive diffusion bags (PDBs) was initiated for VOC sampling to minimize generation of remediation-derived waste, equipment use, and overall field efforts (CH2M HILL, 2014a). Additionally, 1,1,2,2-tetrachloroethane (PCA) and 1,2-dibromomethane were removed from the analyte list in Fiscal Year (FY) 2011 because concentrations were below cleanup levels for four consecutive rounds of sampling.

Sampling locations are shown on **Figure 3-1**. The annual cost of LTM at OU 1 is approximately \$65,000.

Land Use Controls

LUCs will be updated in 2015 based on supplemental investigations that showed groundwater contamination outside of the current LUC boundary (CH2M HILL, 2015a). The current LUCs are shown on **Figure 3-1** and summarized in **Table 3-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

TABLE 3-3
OU 1 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP* Date	Onslow County Registration Date
Non-Industrial Use Control Boundary (Soil)	0.70		
Intrusive Activities Control Boundary (Groundwater)	29	January 2015	Dandina
Aquifer Use Control Boundary (1,000 feet)	720	January 2015	Pending
Industrial/Non-industrial Use Control (VI)	54		

^{*} LUCIP = Land Use Control Implementation Plan

3.5.2 Post-ROD Removal Actions and Pilot Studies

Pilot studies and removal actions were completed within OU 1 under the IRP and at the HPFF under the UST program after the ROD was signed. The locations of pilot studies and the HPFF are shown on **Figure 3-4**.

ES120414012346RAL 3-5

Site 78 North

From 2003 to 2005, an oxygen release compound (ORC) was injected into groundwater using direct-push technology (DPT) methods at 25 locations targeting groundwater with vinyl chloride (VC) concentrations higher than 1,000 μ g/L at Site 78 North (approximately 6 to 44 feet bgs). Approximately 90 pounds of ORC slurry were injected per location, resulting in 2,250 pounds of ORC total. The concentration of VC in groundwater at Site 78 North was reduced by 25 to 50 percent (CH2M HILL, 2005).

Site 78 South

From 2003 to 2005, a hydrogen release compound (HRC) was injected into groundwater using DPT methods into groundwater at 38 locations targeting groundwater trichloroethylene (TCE) concentrations greater than $1,000 \,\mu\text{g/L}$ at Site 78 South (approximately 6 to 50 feet bgs). Approximately 270 to 330 pounds of HRC were injected per location, resulting in 11,100 pounds of HRC total. The concentration of TCE in groundwater at Site 78 South was reduced by an order-of-magnitude at the majority of wells, but dechlorination was not complete and appeared to stall at cis-1,2-DCE (CH2M HILL, 2005).

In 2012, a treatability study was initiated to evaluate potential technologies to treat TCE concentrations ranging from 4,300 to 12,000 μ g/L (CH2M HILL, 2013c). Prior to field implementation, bench scale testing was completed to compare in-situ chemical oxidation (ISCO) via persulfate and enhanced reductive dechlorination (ERD) substrates with and without bioaugmentation. Bench scale testing indicated that ISCO would not be effective in treating the COCs at Site 78 South and ERD with bioaugmentation was the most effective technology. Injections of EHC-L substrate and Terra Systems Incorporated DC (TSI-DC) bioaugmentation culture were initiated in December 2013 into two injection wells screened in the UCH aquifer (50 to 60 feet bgs). Post-injection monitoring is complete and results will be presented in a treatability study report planned for 2015.

Vapor Intrusion Mitigation Systems

Due to the nature of the remediation systems and COCs, the Navy conducted a phased Basewide vapor intrusion (VI) investigation which included buildings within the Site 78 boundary. Based on the results, the VI pathway was not significant; however, the Base elected to install vapor intrusion mitigation systems (VIMS) as a precautionary measure to mitigate the potential for any future risks at Buildings 902, 1005, and 1115 within the Site 78 boundary (CH2M HILL, 2009; 2011). The VIMS consist of sub-slab depressurization systems that place negative pressure beneath the floor slab under the building footprint. Quarterly O&M is ongoing to confirm that the VIMS are operating as designed. The buildings with VIMS in place are shown on **Figure 3-4**.

3.5.3 Progress Since the 2010 Five-Year Review

Issues, recommendations, and follow-up actions from the 2010 FYR are summarized in **Table 3-4**. Additionally, supplemental investigations that were completed at the HPIA since the 2010 FYR are summarized in **Table 3-5**. The current understanding of the conceptual site model (CSM) including potential risk pathways, approximate extent of COCs, and potential sources is shown on **Figure 3-4**.

3-6 ES120414012346RAL

TABLE 3-4 2010 FYR Recommendation/Follow-up Actions

Issues	Recommendations (Milestones)	Date Complete/Current Status
	Update groundwater COCs and cleanup levels to reflect current standards. (2012)	Cleanup levels were updated in the FY 2012 LTM report and the most up to date standards are used in the LTM program
Cleanup levels have changed since the ROD	Collect groundwater samples for metals analysis to evaluate whether any exceedances are site-related or attributable to background. If site-related exceedances are detected, evaluate risks, add metals as COCs to LTM Program, evaluate LUCs, and prepare an ESD. (2013)	Completed in 2013. Groundwater samples were collected from monitoring wells within the LTM program and analyzed for total metals and a human health risk screening (HHRS) was conducted. The HHRS indicated a potential for unacceptable risks to human health from exposure to metals in the surficial aquifer. Based on the results of the HHRS and comparison to historical data, the report recommended to collect groundwater samples for metals from surficial aquifer monitoring wells in the LTM program every 3 years and re-evaluate metals as COCs during FYRs as trends are generated over time (CH2M HILL, 2013b).
LUC boundaries do not encompass extent of contamination	Revise the LUC boundary to encompass extent of contaminated groundwater. (2013)	The supplemental groundwater investigation (SGI, summarized in Table 3-5) was conducted from 2011 through 2014 (CH2M HILL, 2014c) and based on the results, the LUCIP Update was submitted in 2015. The survey plat is currently being completed to update the LUC boundaries. In the interim, current groundwater plumes are maintained in Base GIS for planning purposes.
LTM network does not encompass extent of contaminated groundwater	Monitor for potential downgradient migration and north of Holcomb Boulevard. Assess vertical extent of benzene at IR78-GW04-2. (2012)	 The monitoring network was re-evaluated based on the SGI and, in 2014, the LTM program was updated as follows: In Site 78 North: 3 surficial monitoring wells, 3 UCH monitoring wells, 12 MCH monitoring wells, and 4 LCH monitoring wells were added. In Site 78 South: 5 surficial monitoring wells, 7 UCH monitoring wells, 4 MCH monitoring wells, and 1 LCH monitoring wells were added.
Groundwater extraction	Evaluate recovery well efficiency and groundwater capture zones, and make repairs or changes to optimize mass removal. (2011)	In June 2010, the groundwater and extraction treatment system pumps were cleaned, the pumps in the Site 78 South recovery wells were lowered, and IR78-RW15 was reactivated to improve mass removal and capture zones.
and treatment system data have become asymptotic	Evaluate alternative treatment technologies, if necessary. (2015)	A Treatability Study was initiated in 2012 at Site 78 South to evaluate the overall effectiveness of ERD with bioaugmentation for reducing CVOC mass and to obtain information on design parameters for site-wide implementation as a potential alternative to accelerate site closure. The Treatability Study is currently underway and is anticipated to be completed in 2015.
VI potential	Evaluate and mitigate VI pathway during construction planning. (ongoing)	VI was evaluated during the phased Basewide VI evaluation (CH2M HILL, 2009, 2011, and 2015b). If buildings are planned for construction in the vicinity of the VOC groundwater plume, the potential for a VI pathway is evaluated and mitigated if needed. Base Master Planning maintains current groundwater plume data in the GIS, and all construction projects on-Base go through environmental review.

ES120414012346RAL 3-7

TABLE 3-5
Supplemental Investigations since the 2010 FYR

Investigation	Summary
Contaminant Plume Delineation, OU 1 (Rhēa, 2011)	A field screening was conducted to further delineate VOCs in groundwater using DPT. Analytical results suggested that VOC contamination was present outside of the current LUC boundaries and recovery well and LTM network. Further investigation to confirm these results was recommended.
Preliminary Assessment (PA)/Site Inspection (SI) for Hadnot Point Construction Area (HPCA) (CH2M HILL, 2010) and Risk Assessment Update (CH2M HILL, 2012)	During a Military Construction (MILCON) PA/SI for the HPCA (CH2M HILL, 2010) located within the HPIA of Site 78, potentially unacceptable risks were identified based on future residential exposure to polycyclic aromatic hydrocarbons (PAHs) and metals in surface soil and ecological exposure to metals in surface water and sediment located in a drainage feature. Additional risk evaluation was recommended and an ecological site survey was conducted. The evaluation concluded that concentrations of PAHs and metals detected in surface soil appear to be ubiquitous in nature and are present across the HPCA with no identified source; the potential human health risks were based on a reasonable maximum exposure, assuming direct contact with the highest concentrations, whereas the central tendency exposure, based on more realistic exposure duration, soil ingestion rates, and average concentrations, were within USEPA's acceptable ranges. Overall, risks to ecological receptors from exposure to surface soil, sediment, and surface water at the HPCA are considered low and significant impacts to receptor populations are unlikely. Based on these conclusions, NFA was recommended in the HPCA.
Solid Waste Management Unit (SWMU) 574 RFI (CH2M HILL, 2013a)	Stained soils were discovered during utility excavation activities in 2010 and the area was investigated under the Resource Conservation and Recovery Act (RCRA) program as SWMU 574. SWMU 574 is an open lot that was originally used for storage of vehicles and equipment within the HPIA (Figure 3-1). Soil and groundwater samples were collected. SVOCs (PAHs) and PCBs were the primary contaminants in soil and BTEX and CVOCs were detected in groundwater. The HHRA identified potential future risks to residents from exposure to SVOCs in soil and VOCs in groundwater. Because the groundwater COCs are similar to Site 78 and SWMU 574 is located within the OU boundary, the SWMU was transferred to the CERCLA program in June 2013.
SGI (CH2M HILL, 2014d)	In 2011, an SGI was initiated to investigate if the LTM program and LUCs remain protective in the short term and support the future evaluation of alternative treatment technologies for long-term protectiveness. The investigation included monitoring well installation, groundwater sampling, a passive soil gas (PSG) survey, and a membrane interface probe (MIP) investigation. The results of the investigation identified CVOC contaminant plumes in Site 78 North and South that were different than defined by previous investigations. As a result, recommendations for changes were made for the LTM program and LUC boundaries.

3.6 Technical Assessment

Is the remedy functioning as designed?

No. Based on the review of documents, LTM results, ARARs, risk assumptions, SIs, and O&M costs, the remedy at OU 1 is not functioning as designed. As detailed below, the treatment system has reached an asymptotic state and supplemental investigations indicate that COCs are deeper and more widespread than at the time of the ROD.

Treatment System

O&M data indicate that the mass recovery is asymptotic, and the 2010 system modifications and reactivating RW15 did not improve long-term recovery rates. Furthermore, the treatment system was designed to prevent migration of the plumes in the surficial aquifer and remediate groundwater for future potable use of the aquifer. At the time of the ROD, the highest concentrations of primary COCs were reported in samples from the surficial aquifer and lower concentrations were reported in the UCH aquifer (Tables 3-6 and 3-7). Data collected during supplemental investigations and LTM indicate that concentrations of COCs are several orders-of-magnitude higher in deeper aquifer intervals than the recovery wells are designed to capture (Figures 3-5 through 3-8). The SGI data also suggest the surficial aquifer plume has migrated downgradient from the Site 78 South recovery well system, indicating that the system is not effectively capturing and containing the surficial aquifer groundwater contamination.

3-8 ES120414012346RAL

TABLE 3-6
Maximum Concentration of Select COCs Detected During the RI and SGI (Site 78 North)

COC (μg/L)		icial feet bgs)		'MCH feet bgs)	MCH (100 to 155 feet bgs)			
	RI (1993)	SGI (2011) ¹	RI (1993)	SGI (2011) ¹	RI (1993)	SGI (2011) ¹		
TCE	440	3.3	ND	15	6	9,500		
cis-1,2-DCE	14,000	110	12 ²	420	1	6,700		
VC	97	25	33	250	ND	110		
Benzene	77	53	7	180	35	5.3		
Toluene	210	17	3	5.5	ND	16		
Ethylbenzene	540	1.2	ND	1.6	ND	10		
Xylenes	1,300	17	3	11	ND	12		

ND - not detected

TABLE 3-7
Maximum Concentration of Select COCs Detected During the RI and SGI (Site 78 South)

COC (µg/L)		icial feet bgs)		/MCH feet bgs)	MCH (80 to 125 feet bgs)			
	RI (1993)	SGI (2011) ¹	RI (1993)	SGI (2011) ¹	RI (1993)	SGI (2011) ¹		
TCE	2,100	420	6	12,000	ND	28		
cis-1,2-DCE	2,400	500	ND	360	3	14		
VC	ND	140	ND	180	ND	ND		
Benzene	ND	220	5	1,100	30	ND		
Toluene	ND	210	ND	15,000	ND	0.68 J		
Ethylbenzene	ND	1,900	ND	1,500	ND	ND		
Xylenes	ND	8,200	ND	5,500	ND	ND		

ND - not detected

Long-term Monitoring and Land Use Controls

The LTM network was expanded and LUCs are being updated based on supplemental investigations completed at OU 1. Groundwater plumes are maintained in Base GIS and Master Planning to prevent exposure to COCs and maintain protectiveness while the LUCs and survey plat are being finalized. Since LTM was complete at Site 24 and there are no other media of concern at the site, it is recommended to officially document remedy completion and remove from future FYRs.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The cleanup levels for groundwater were identified as the more conservative of the Federal Maximum Contaminant Levels (MCLs) or NCGWQS at the time the ROD was signed. Since that time, the standards for one pesticide (heptachlor epoxide), one VOC (toluene), and one metal (vanadium) have been updated and are more conservative as listed in **Table 3-1**. LTM for pesticides was discontinued previously based on four consecutive

ES120414012346RAL 3-9

¹Higher concentrations from the SGI may be the result of expanding the monitoring well network over time.

²total 1,2-DCE

¹Higher concentrations from the SGI may be the result of expanding the monitoring well network over time.

identified in the ROD. In addition, several VOC constituents were detected above the MCLs/NCGWQS and added as COCs since the ROD (**Table 3-1**).

The cleanup levels for pesticides in soil were identified as the USEPA Region III risk-based concentrations (RBCs) for industrial soil. The confirmation soil sample results documenting the removal of the pesticide and PCB-contaminated soil indicate that the cleanup levels identified in the ROD were met (OHM, 1996). Although the recent USEPA RSLs for industrial soil for dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyltrichloroethane (DDT) are more conservative (**Table 3-1**), the area was restored with clean fill following the RA, and LUCs for non-industrial use remain in place and are protective.

The RAOs used at the time of selection are still valid. However, additional RAOs may be warranted to address the deeper contaminant mass and VI pathway.

Changes in Exposure Pathways: Yes. The VI pathway was investigated at Buildings 901, 902, 903, 1502, 1601, 1603, 1606, and 1707. Although the VI pathway was not significant, a VIMS was installed at Building 902 as a precautionary measure. Periodic monitoring was recommended at Building 1601 to assess temporal variability and to monitor the potential for a future VI pathway (CH2M HILL, 2015b). Follow-up monitoring is scheduled for fiscal year 2018.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs identified in the ROD (Table 2-1), groundwater cleanup levels were identified as the more conservative of the Federal MCLs or the NCGWQS value. Groundwater concentrations measured during LTM continue to exceed cleanup levels and LUCs will remain in place until they are below the most up-to-date standards. Thus, toxicity changes would not affect the protectiveness of the remedy.

Has any other information come to light that could question the protectiveness of the remedy?

Yes. Supplemental investigations have indicated that the groundwater COC plumes are deeper and more widespread than conditions at the time of the ROD. The VI pathway has the potential to become complete at OU 1 and an RAO and LUCs should be added to include evaluating the potential for VI pathways if building or land use changes and VI mitigation if needed. Additionally, groundwater has not been sampled for 1,4-dioxane analysis and 1,1-DCE and 1,1-DCA are COCs in groundwater at OU 1.

3.7 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 1 are summarized in Table 3-8.

TABLE 3-8
OU 1 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight	Milestone Date	Affects Protectivenes (Y/N)			
		responsible	Agency	Date	Current	Future		
Cleanup levels were met and LTM is complete at Site 24 but remedy completion has not been formally documented	Prepare a Remedial Action Completion Report (RACR) to document remedy completion at Site 24	Navy/Base	USEPA/State	6/30/2016	N	N		
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non- Industrial Use Control Boundary (VI).	Navy/Base	USEPA/State	6/30/2016	N	Υ		
An RSL was established for 1,4-dioxane and indicator constituents are present in groundwater	Collect groundwater samples for 1,4-dioxane	Navy/Base	USEPA/State	9/30/2018	N	Υ		

3-10 ES120414012346RAL

TABLE 3-8
OU 1 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party	Oversight	Milestone	Affects Protectiveness (Y/N)			
		Responsible	Agency	Date -	Current	Future		
The remedy is not functioning as designed and RAOs will not be met within a reasonable timeframe because recently discovered source areas and deeper groundwater contamination are not being addressed	Continue groundwater remedy evaluation to determine what changes are needed and refine the CSM to evaluate extent of groundwater contamination and exposure pathways. Develop a Revised Proposed Plan and ROD Amendment or explanation of significant differences (ESD) as necessary	Navy/Base	USEPA/State	12/30/2020	N	Υ		

3.8 Statement of Protectiveness

The remedy for soil at OU 1 is protective of human health and the environment because exposure pathways that could result in unacceptable risk are being controlled and LUCs preventing exposure are in place.

The remedy for groundwater at OU 1 currently protects human health and the environment in the short-term because LUCs are in place and are being updated to prevent current exposure to COCs in groundwater. To facilitate protectiveness, Base Master Planning maintains all current VOC plume data in the GIS and all construction projects go through environmental review. In order for the remedy to be protective in the long-term, the CSM should be refined, the RAOs updated, and the site remediation strategy revisited to address the current extent of groundwater contamination.

3.9 References

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ES120414012346RAL 3-11

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USMC. 1998. Notice of Non-Significant Change: OU 1 (Site 24). February 3, 1998.

3-12 ES120414012346RAL

TABLE 3-1
Cleanup Levels for OU 1 (Sites 21, 24, and 78)
Five-Year Review

Media	606-	ROD Cleanup Levels	Curren	t Cleanup Level	
iviedia	COCs	(Baker, 1994)	Concentration	Reference	
	VOCs		•		
	Benzene	1	1	NCGWQS	
	1,2-dibromo-3-chloropropane		0.04	NCGWQS	
	1,2-Dibromoethane		0.02	NCGWQS	
	1,1-Dichloroethane		6	NCGWQS	
	1,2-Dichloroethane		0.4	NCGWQS	
	1,1-Dichloroethene		7	NCGWQS/MCL	
	1,2-Dichloroethene	70	70	MCL	
	cis-1,2-Dichloroethene		70	NCGWQS/MCL	
	trans-1,2-Dichloroethene		100	NCGWQS/MCL	
	Ethylbenzene	29	600	NCGWQS	
	Isopropylbenzene		70	NCGWQS	
	1,1,2,2-Tetrachloroethane		0.2	NCGWQS	
Croundinator (u.g./l.)	Methylene chloride		5	NCGWQS	
Groundwater (μg/L)	Tetrachloroethene	0.7	0.7	NCGWQS	
	Toluene	1,000	600	NCGWQS	
	Trichloroethene	2.8	3	NCGWQS	
	Vinyl chloride	0.015	0.03	NCGWQS	
	Xylenes (total)	400	500	NCGWQS	
	Pesticides				
	Heptachlor epoxide	0.2	0.004	NCGWQS	
	Metals				
	Arsenic	50	10	NCGWQS/MCL	
	Barium	1,000	700	NCGWQS	
	Beryllium	4	4	MCL	
	Chromium	50	10	NCGWQS	
	Manganese	50	50	NCGWQS	
	Vanadium	110	8.6	RSL-Tapwater	
	PCBs				
	PCBs	10,000	10,000	Action Level for Low Occupancy Land Use	
Soil (mg/kg)				(USEPA, 1990)	

Notes:

Metals, TDS, and TSS were removed as COCs from the ROD and LTM Program (USMC, 1997)

-- COC identified post-ROD based on exceedances of current cleanup levels during LTM

4,4-DDD

4,4-DDT

Chlordane (total)

Shading indicates cleanup levels achieved/remain protective for soil per Closeout Report (OHM, 1996) and for groundwater per Notice of NonSignificant Changes (USMC, 1997)

12,000

8,400

2,200

9,600

8,600

8,000

Cleanup Level Reference Dates:

MCL (May 2009)

NCGWQS (April 2013)

RSL (November 2014)

RSL-Industrial Soil

RSL-Industrial Soil

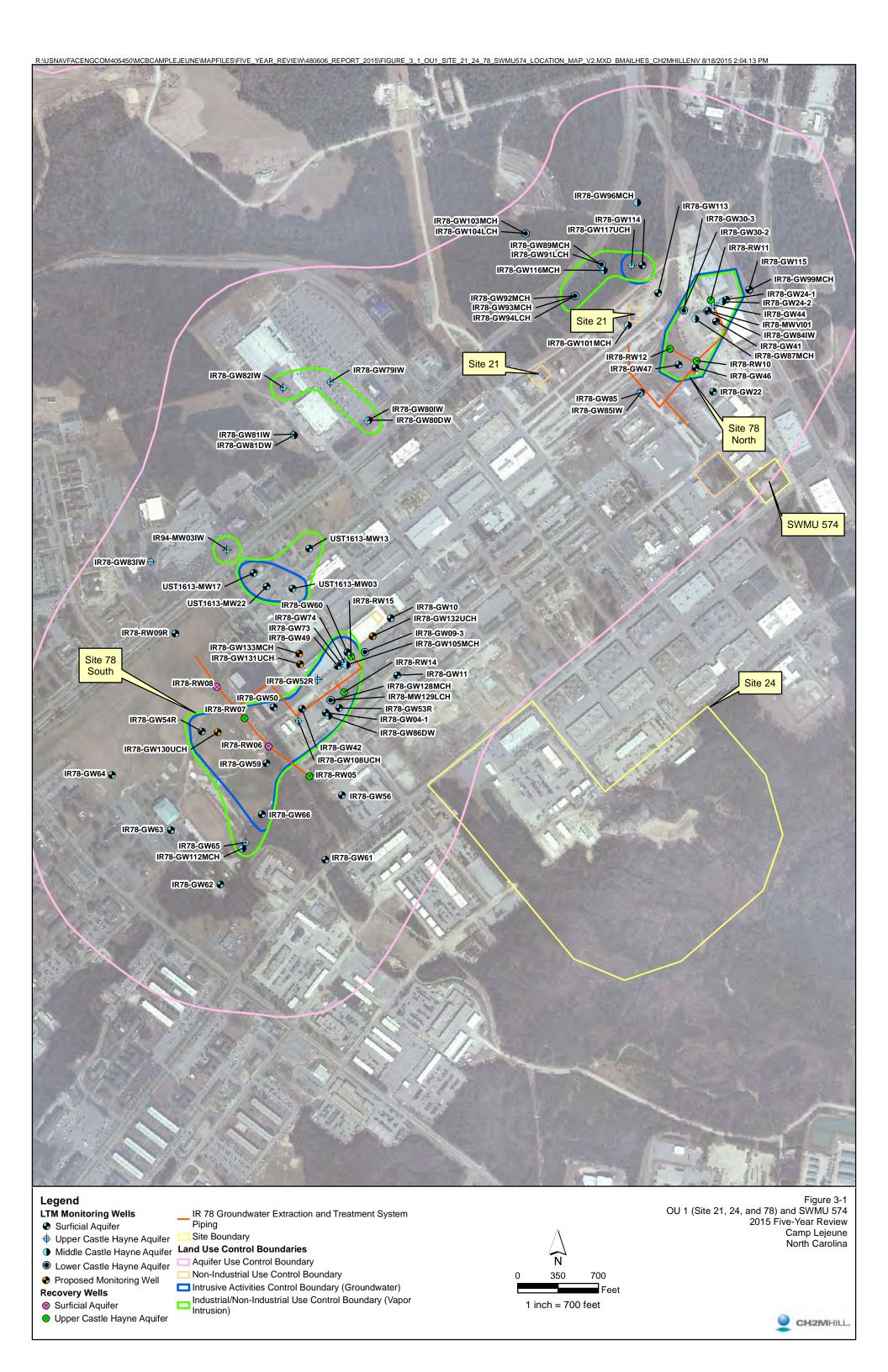
RSL-Industrial Soil

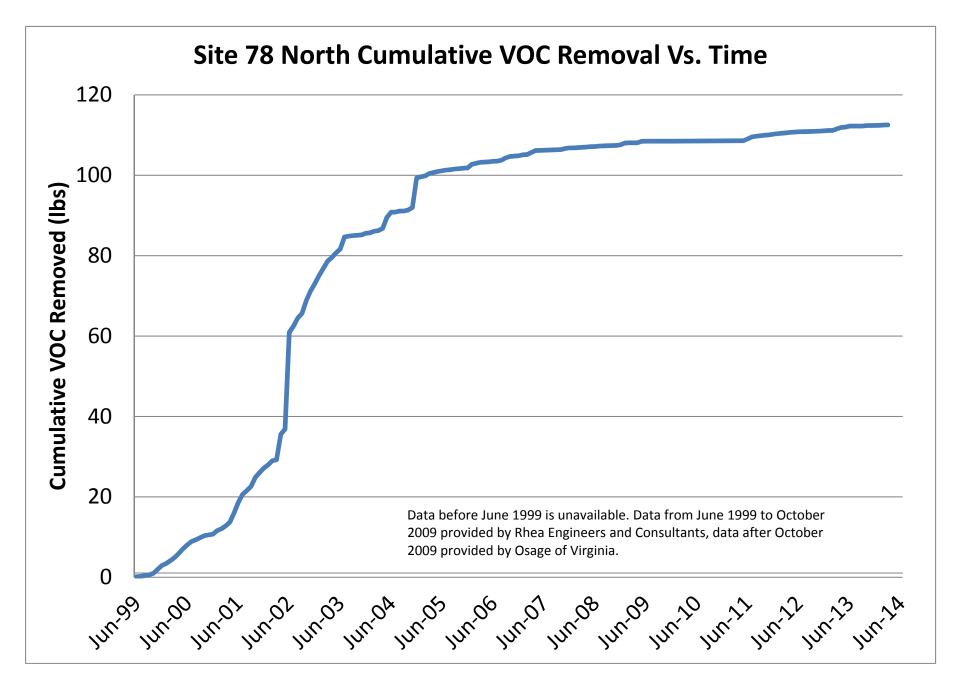
TABLE 3-2
OU 1 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

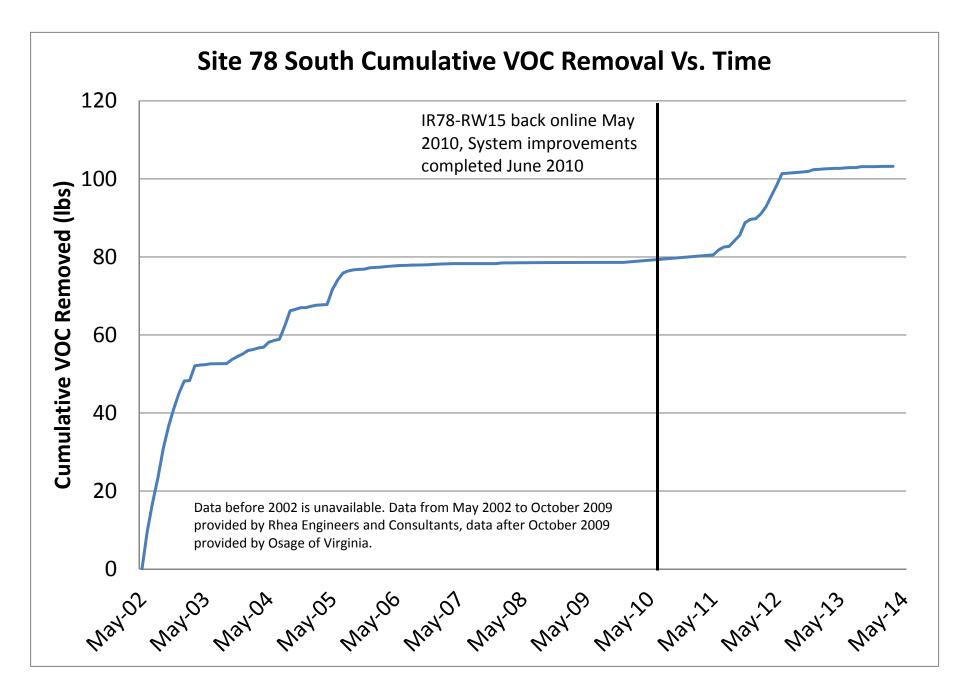
Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
21		Potential unacceptable ecological risks from pesticides and PCBs in soil.		To treat or remove contaminated soil from designated areas of concern.	Soil Removal	Soil removal from areas of concern to meet industrial standards.	Industrial
78	Soil	PCBs exceeded industrial standards at isolated locations.		To prevent current or future exposure to contaminated soils.	LUCs	Maintain non-industrial land use controls and conduct quarterly monitoring.	Land Use
				To prevent current or future exposure to the contaminated	Groundwater Extraction and	Operate until after groundwater COCs are at or below respective cleanup levels. Perform routine maintenance. Monitor VOC mass removal in conjunction with LTM data to evaluate system effectiveness.	
21 24 78	Potential unacceptable risks to future residents from exposure to metals and VOCs in groundwater. 24 Groundwater	Potential unacceptable risks to future residents from Industrial exposure to metals and VOCs in groundwater.	groundwater. To remediate groundwater contamination for future potential use of the aquifer.	LTM	Groundwater LTM to monitor treatment system performance and COC concentration trends over time until groundwater COCs are at or below cleanup levels for 4 consecutive monitoring events. LTM at Site 24 is complete, site is NFA.	UU/UE	
				LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.		
		To prevent future exposure to COCs in indoor air via the VI pathway.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.			

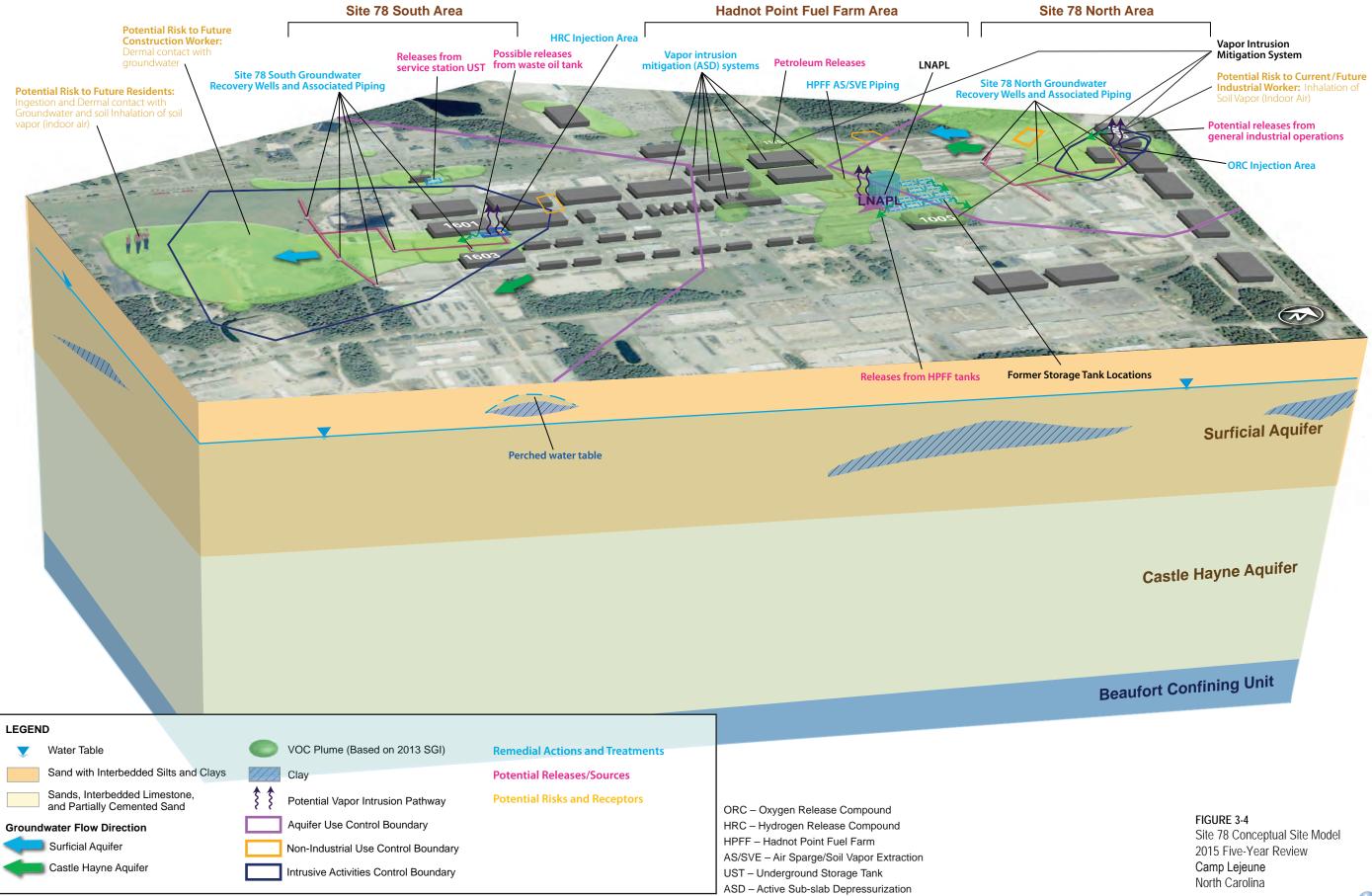
Notes

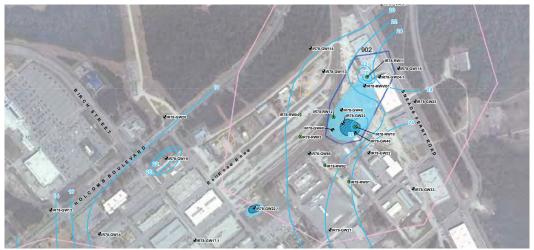
Shading indicates Risks/Basis of Action resulting from changing site conditions, exposure pathways, or assumptions that were not present at the time of the ROD. The proposed RAO, Remedy Component, and Performance Metric are included.







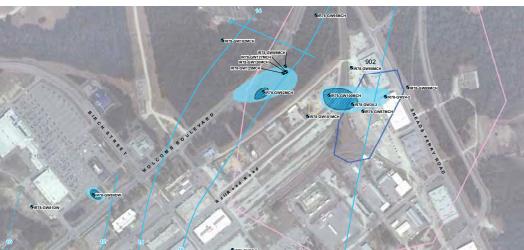




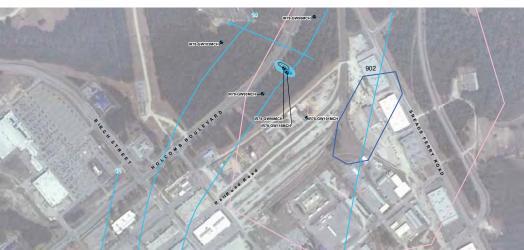
Surficial Aquifer 0'-30' bgs



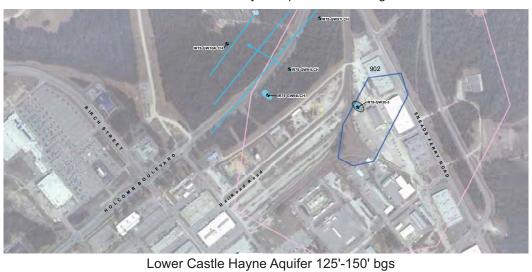
Upper Castle Hayne Aquifer 30'-60' bgs



Middle Castle Hayne Aquifer 70'-90' bgs



Middle Castle Hayne Aquifer 90'-125' bgs



- Monitoring Well
- Monitoring Well not in LTM
- Recovery Well
- Estimated direction of groundwater flow

Potentiometric surface contour

Land Use Control Boundaries

Aquifer Use Control Boundary

Non-Industrial Use Control Boundary

Note: Detections of BTEX below NCGWQS are shown to further refine the conceptual site model

Intrusive Activities Control Boundary (Groundwater)

BTEX Plume Concentrations

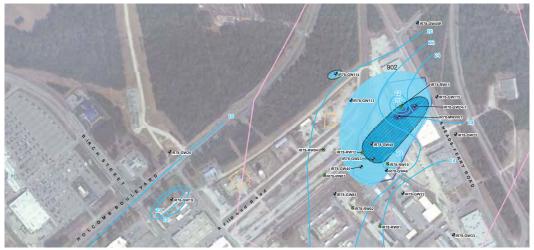
0-10 μg/L

10-100 μg/L 100-1,000 μg/L **Exceeds NCGWQS**

○ N 0 200 400

FIGURE 3-5 Supplemental Groundwater Investigation BTEX Plume Maps - Site 78 North 2015 Five-Year Review Camp Lejeune North Carolina





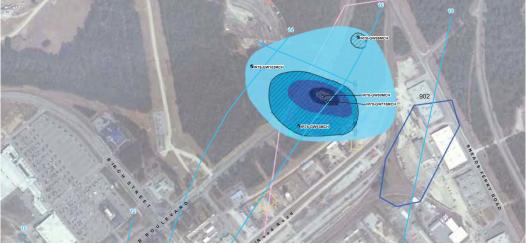
Surficial Aquifer 0'-30' bgs



Upper Castle Hayne Aquifer 30'-60' bgs



Middle Castle Hayne Aquifer 70'-90' bgs



Middle Castle Hayne Aquifer 90'-125' bgs



- Monitoring Well
- Monitoring Well not in LTM
- Recovery Well
- Estimated direction of groundwater flow Potentiometric surface contour

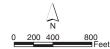
Land Use Control Boundaries

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)
- Non-Industrial Use Control Boundary
- Note: Detections of CVOCs below NCGWQS are shown to further refine the conceptual site model

Total Chlorinated VOC

Plume Concentrations

- 0-10 μg/L
- 10-100 μg/L
- 100-1,000 μg/L 1,000-10,000 μg/L >10,000 μg/L
- **Exceeds NCGWQS**

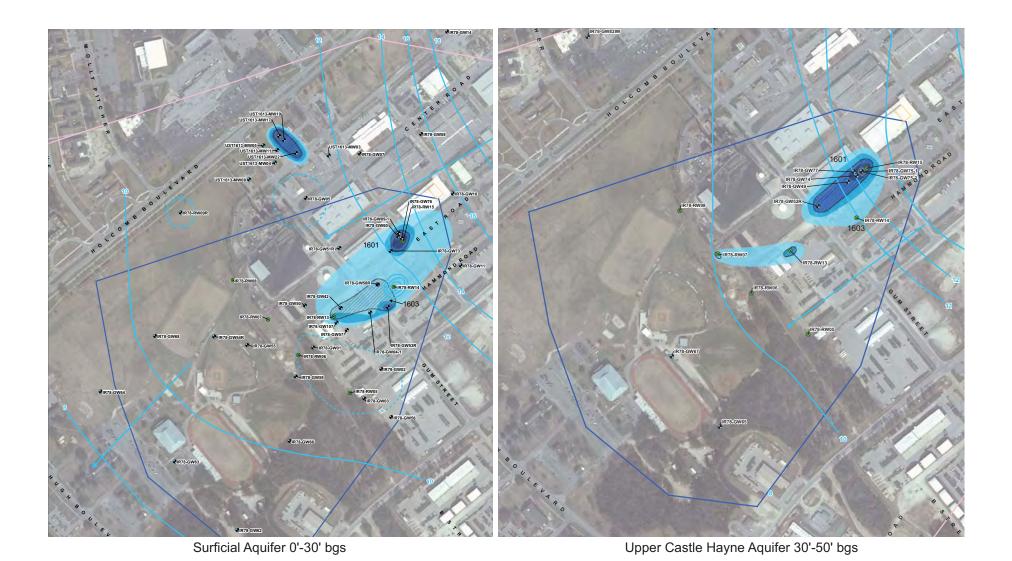


Supplemental Groundwater Investigation Chlorinated VOC Plumes – Site 78 North 2015 Five-Year Review

Camp Lejeune North Carolina

FIGURE 3-6





Upper Castle Hayne Aquifer 50'-60' bgs

Middle Castle Hayne Aquifer 60'-125' bgs

- Monitoring Well
- Monitoring Well Not in LTM
- Monitoring Well Measured LNAPL
- Recovery Wells
- Estimated direction of groundwater flow
- Potentiometric surface contour Area of perched groundwater
- Groundwater depression

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)

Note: Detections of BTEX below NCGWQS are shown to further refine the conceptual site model

BTEX Plume Concentrations

150 300

Exceeds NCGWQS

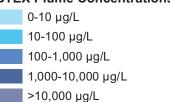
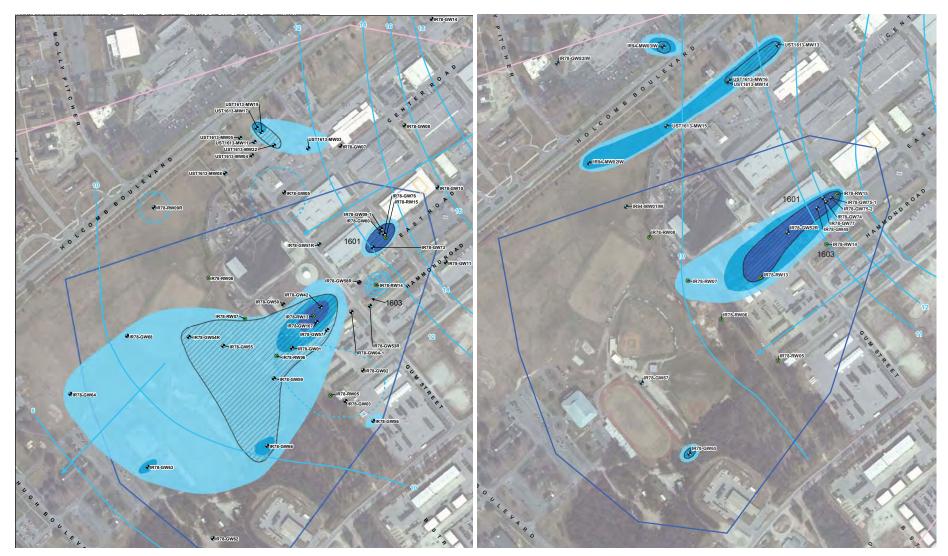


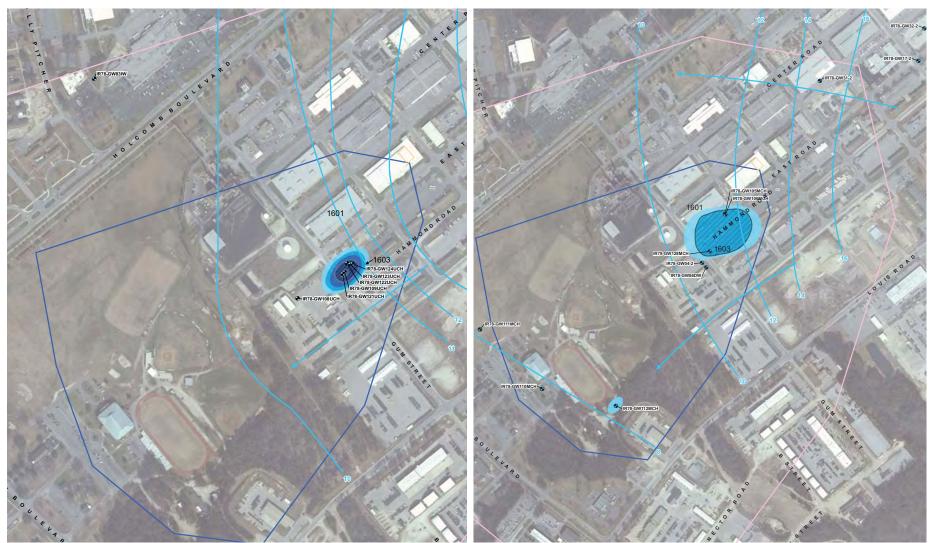
FIGURE 3-7 Supplemental Groundwater Investigation BTEX Plume Maps - Site 78 South 2015 Five-Year Review Camp Lejeune North Carolina





Surficial Aquifer 0'-30' bgs

Upper Castle Hayne Aquifer 30'-50' bgs



Upper Castle Hayne Aquifer 50'-60' bgs

Middle Castle Hayne Aquifer 60'-125' bgs

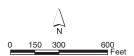
- Monitoring Well
- Monitoring Well Not in LTM
- Monitoring Well Measured LNAPL
- Recovery Wells
- Estimated direction of groundwater flow
- Potentiometric surface contour
- Area of perched groundwater

Groundwater depression

- Land Use Control Boundaries

 Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)

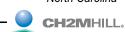
Note: Detections of CVOCs below NCGWQS are shown to further refine the conceptual site model



Chlorinated VOC Plume Concentrations

- 0-10 μg/L
- 10-100 μg/L
- 10-100 μg/L 100-1,000 μg/L
- 1,000-10,000 µg/L
- >10,000 µg/L Exceeds NCGWQS

FIGURE 3-8
Supplemental Groundwater Investigation
Chlorinated VOC Plume Maps – Site 78 South
2015 Five-Year Review
Camp Lejeune
North Carolina



Operable Unit 2 (Sites 6, 9, and 82)

4.1 Site History and Background

OU 2 is within the Mainside area of the Base (Figure 1-2). OU 2 consists of three sites (Sites 6, 9, and 82) that have been grouped together because of their proximity to one another. Site 9, Fire Fighting Training Pit at Piney Green Road, was granted NFA because it is an active site and is not included in the FYR. Military Munitions Response Program (MMRP) Site UXO-22 is located within the OU 2 boundary and is currently under investigation (Figure 4-1).

Site 6 — Lots 201 and 203 are approximately 177 acres (Figure 4-1). From the 1940s to the late 1980s, Site 6 was used for disposal and storage of wastes and supplies, including pesticides, transformers containing PCBs, solvents, electrolytes, waste oils, and munitions items. Currently, Lot 201 is used to store military equipment, vehicles, hydraulic oils, and other "non-hazardous" supplies. Approximately 21 acres of Lot 203 were temporarily used by the Defense Reutilization and Marketing Office (DRMO) for staging operations between 2001 and 2012. In addition, Lot 202 is located in the western portion of the site, adjacent to Lot 201. Since 2002, Lot 202 has been used to store a variety of shipping containers and other surplus equipment.

Site 82 — Piney Green VOC Area is approximately 30 acres (Figure 4-1). Before the late 1980s, much of the site was reportedly used for storage, disposal, and handling of potentially hazardous waste and material. Site 82 was identified during the Confirmation Study at Site 6 in 1986, when debris, including spent ammunition casings and empty or rusted drums, was discovered on the ground surface. Some of the drums were marked as "lubrication oil" and "anti-freeze."

4.2 Site Characterization

The findings from various investigations at OU 2 that are pertinent to the FYR are summarized in this section.

iizii iiyoloal ollalaotollotloo	4.2.1	Physical	Characteristics
---------------------------------	-------	-----------------	-----------------

1983	•IAS (Site 6 & 9)			
1984- 1987	Confirmation Study (Site 6 & 9)			
1989	•Soil Gas Survey (Site 6)			
1991	•SI (Site 82)			
1992- 1993	•RI/FS			
1993	•PRAP and ROD, NFA (Site 9)			
1994- Present	•RIP (Site 6 & 82)			
1994- 1995	•TCRA – Soil and Drum Removal (Site 6 & 82)			
1995	•SVE (Site 82)			
1996- Present	•Groundwater extraction and treatment system (Site 82)			
1997- Present	•LTM (Site 6 & 82)			
2002- 2012	Chlorobenzene Investigation (Site 6)			
2007- 2008	•Groundwater Pilot Study - ERD (Site 82)			
2007- 2011	Basewide VI Evaluation			
2008- 2011	Supplemental Source Investigation (Site 82)			
2010	•Environmental Condition of Property Study Lot 203 (Site 6)			
2011	•TCRA – Chlorobenzene Drum Removal (Site 6)			
2012	•Historical Metals Evaluation - Groundwater and Soil (Site 6 & 82)			
2012- Present	•Supplemental Investigation (Site 6 & 82)			
2014	•Environmental Condition of Property Lot 202 (Site 6)			

• Surface Features – Site 6 is relatively flat and consists of unpaved storage lots in the central area with wooded areas in the northern and southern areas of the site. An ephemeral drainage feature is located in the northwest section of Site 6 and runs through Site 82 to discharge into Wallace Creek. Bearhead Creek, a tributary of Wallace Creek, lies within the southern portion of Site 6.

4-1 ES120414012346RAL

Site 82 is primarily flat with a steep drop in elevation toward Wallace Creek to the north. The site is wooded with a cleared area to the south where Navy environmental contractor trailers and the groundwater treatment plant are located.

Geology and Hydrogeology – Subsurface conditions generally consist of Coastal Plain deposits comprising silty sands, clays, and poorly to moderately indurated sandy limestone, with varying amounts of shell fragments. Groundwater is typically encountered at depths ranging from 8 to 22 feet bgs and flows to the northwest, towards Wallace Creek. The surficial aquifer extends to a depth of approximately 25 feet bgs, and transitions into the Castle Hayne aquifer. The UCH aquifer is present from approximately 25 feet bgs to approximately 90 feet bgs, where the LCH aquifer is encountered. The LCH aquifer extends to approximately 250 feet bgs (CH2M HILL, 2015).

4.2.2 Land Use

- Current Land Use Lot 201 (Site 6) is used to store military equipment, vehicles, hydraulic oils, and other "non-hazardous" supplies. Lot 202 (adjacent to Lot 201) is a storage area for shipping containers and other surplus equipment. Most of Lot 203 and the area to the north to Wallace Creek (Sites 6 and 82) is vacant and consists of open fields and wooded areas; a portion of Lot 203 is also used for Navy contractor field trailers and the groundwater treatment plant (Figure 4-1).
- Future Land Use There are no anticipated changes in land use.

4.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 2 RI report (Baker, 1993a) and ROD (Baker, 1993b).

Site 6

- Pesticides, PCBs, and metals were detected in soil, and VOCs and metals were detected in surficial aquifer groundwater at Site 6. Drums and other waste materials were identified on the surface and subsurface (via geophysical investigation) that presented a potential source of contamination to soil and groundwater. Metals and pesticides were detected in sediment from Bearhead Creek (Baker, 1993a).
- An HHRA and ERA were completed as part of the 1993 RI. Potential unacceptable human health risks were identified for current Base personnel and future residents due to exposure to metals and VOCs in surficial aquifer groundwater at Site 6. The ERA concluded that concentrations of inorganics in surface water and inorganics and organics in sediment in Bearhead Creek presented a moderate to high risk to ecological receptors if they were representative of long-term conditions. However, based on ecological studies conducted, there did not appear to be any impact on the fish or benthic communities due to site contamination (Baker, 1993a). Although no unacceptable risks were identified from exposure to contaminants in soil, several areas were identified for removal of pesticide and PCB-contaminated soil based on comparison to remedial goals selected during the Feasibility Study (FS) (Baker, 1993b).

Site 82

- PCBs and metals were detected in soil and VOCs were detected in deep (all zones of the Castle Hayne aquifer)
 groundwater at Site 82. Drums and other waste materials were identified on the surface and subsurface (via
 geophysical investigation) that presented a potential source of contamination to groundwater. Metals and
 VOCs were detected in surface water and PAHs were detected in sediment at Wallace Creek (Baker, 1993a).
- An HHRA and ERA were completed as part of the RI. Potential unacceptable human health risks were identified for current Base personnel and future residents due to exposure to metals and VOCs in surficial and Castle Hayne aquifer groundwater at Site 82. The ERA concluded that concentrations of inorganics in surface water and inorganics and organics in sediment in Wallace Creek presented a moderate to high risk to ecological receptors if they were representative long-term conditions. However, based on ecological studies conducted, there did not appear to be any current (at the time of the RI) impact on the fish or benthic communities due to site contamination (Baker, 1993a).

4-2 ES120414012346RAL

4.3 Remedial Action Objectives

The ROD addressing groundwater and soil at OU 2 was signed in 1993 (Baker, 1993c). The RAOs identified for OU 2 were:

- Prevent current and future exposure to contaminated soil and groundwater.
- Remediate groundwater for future use of the aquifer.
- Treat or remove contaminated soil.

The cleanup levels for OU 2 are presented in Table 4-1.

4.4 Remedial Actions

The OU 2 RA components and expected outcomes are summarized in **Table 4-2**. The RA for OU 2 included the following major components:

- Excavation and offsite disposal of PCB and pesticide-contaminated soil to industrial levels.
- Installation and operation of a groundwater extraction and treatment system to remove VOCs in the surficial and Castle Hayne aguifers at Site 82.
- LTM of groundwater and surface water in Wallace Creek and the nearby active water supply wells to monitor the effectiveness of the treatment system at Site 82.
- LTM of groundwater to evaluate COC concentrations at Site 6.
- Soil vapor extraction (SVE) to treat approximately 16,500 cubic yards of VOC-contaminated soils at Site 82.
- LUC implementation for soil and groundwater as follows:
 - Prohibit the withdrawal and any use of groundwater, except for environmental monitoring, from the surficial and Castle Hayne aquifers within 1,000 feet of the estimated extent of impacted groundwater.
 - Prohibit use of water supply wells in the vicinity of OU 2 as well as the installation of new supply wells.
 - Restrict intrusive activities within the vicinity of the estimated impacted groundwater extent.
 - Restrict soil intrusive activities and prohibit non-industrial land use within the extent of impacted soils
 which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes,
 and day care facilities.

4.5 Remedy Implementation

Soil and Debris Removal - OU 2

A time-critical removal action (TCRA) was conducted in 1994 and 1995 to remove aboveground storage tanks (ASTs), drums, and other containers that presented potential ongoing sources to soil and groundwater before the ROD was finalized. Approximately 2,655 cubic yards of contaminated soil and debris, including drums containing 4,4'-DDT, empty drums, communication wire, spent munitions casings, and batteries, were removed from trenches excavated at both sites (OHM, 1997). The approximate locations of removal trenches are shown on **Figure 4-1**.

Groundwater Extraction and Treatment System – Site 82

Full-scale operation of the groundwater extraction and treatment system began in July 1996. Groundwater from the surficial (IR06-SRW01), shallow UCH (IR06-SRW02 through –SRW06), deep UCH (IR06-DRW01 through – DRW03) and LCH (IR06-DRW04) recovery wells and sump is treated as follows:

ES120414012346RAL 4-3

Surficial and shallow UCH wells and sump:

- 1. Holding Tank/Reactivation Tank
- 2. Clarifier
- 3. 145 Tank
- 4. 110 Tank

Surficial and shallow UCH wells, deep UCH and LCH wells, and sump:

- 5. 110 Tank
- 6. Air Stripper
- 7. 220 Tank
- 8. Cartridge Filters (in parallel)
- 9. Carbon Vessels (in parallel)
- 10. Effluent Holding Tank
- 11. Effluent (to Wallace Creek)

Sludge collected from the clarifier is passed through filter socks and the filtered fluid is recirculated through the treatment system via the sump. Effluent levels for COCs are listed in **Table 4-3**.

Soil Vapor Extraction – Site 82

SVE was conducted in 1995 to treat approximately 16,500 cubic yards of VOC-contaminated soils (**Figure 4-1**). The system consisted of a single horizontal injection well, an array of eight vertical extraction wells, a piping and manifold system, a vapor/liquid separator, a vacuum blower sized to produce 1,500 actual cubic feet per minute at 15 inches of mercury, and a vapor phase granular activated carbon filter (OHM, 1995a). The SVE system at Site 82 operated for 6 months, from April to November 1995. An interim report indicated that remedial goals were reached for all constituents with the exception of tetrachloroethene (PCE) (OHM, 1995b).

Long-term Monitoring and Land Use Controls – OU 2

LTM was initiated in 1996. LUCs were implemented at OU 2 in 2001 and updated in 2002 (Baker, 2002). LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in Base Master Planning and GIS.

4.5.1 Remedy Operation and Maintenance

Groundwater Extraction and Treatment System - Site 82

Daily and weekly treatment system inspections include: recording readings for the well totalizers; recording pressure readings for the process pumps, cartridge filters, and carbon filters; and observing the condition of other plant and health and safety equipment. Routine maintenance consists of system checks, bag filter replacement, sump cleaning, and backwashing the carbon vessel. Other maintenance includes servicing and replacing pumps, cleaning tank floats, and other as-needed repairs. Monthly O&M reports are provided to the Partnering Team and are included as attachments to the annual LTM reports.

The Lot 203 water treatment plant currently treats groundwater from ten recovery wells (IR06-SRW01 through IR06-SRW06 and IR06-DRW01 through IR06-DRW04) (**Figure 4-1**). During 2013, these recovery wells treated an average of 5,000,000 gallons of water per month, and with an average influent concentration of 4,854 μ g/L from the shallow and 2,518 μ g/L from the deep recovery wells, approximately 121 pounds of VOCs were removed per month (CH2M HILL, 2014a) (**Figure 4-2**). The annual O&M cost for the Site 82 treatment system is approximately \$240,000, which is approximately \$166 per pound of VOCs removed.

In July 2014, 1,1,2,2-PCA in the effluent was 7.9 μ g/L, exceeding the NC surface water quality standard (NCSWQS) of 4 μ g/L (Osage, 2014). The NCSWQS was selected as the effluent limit for 1,1,2,2-PCA because the constituent was added as a COC after the ROD was signed based on exceedances of the NCGWQS during previous LTM sampling. The suspected cause of the exceedance was breakthrough from the carbon vessels and the system was shut down until the carbon vessels were replaced in October 2014. The Partnering Team recommended a review of current NCSWQS for streams and revisiting the effluent levels for the Site 82 treatment system.

4-4 ES120414012346RAL

Long-term Monitoring

Site 6

LTM at Site 6 initially consisted of collecting groundwater samples from 7 surficial, 1 UCH, and 1 LCH aquifer monitoring wells. In 2000, groundwater samples collected from monitoring well IR06-GW16 contained chlorobenzene at a concentration of 57,000 μ g/L (previous detections were several orders of magnitude lower). A series of investigations was completed from 2002 to present. LTM was discontinued in 2012 and reinstated in 2014 with an expanded network to encompass the current extent of contamination. The LTM network currently includes 6 surficial, 10 UCH, and 5 LCH aquifer monitoring wells. The LTM network will be updated as necessary based on the results of supplemental investigations currently underway. Groundwater samples are collected annually and are analyzed for VOCs. Groundwater samples collected from surficial aquifer monitoring wells are analyzed for metals every five years (CH2M HILL, 2014b).

Sampling locations are shown on Figure 4-1. The annual cost of LTM at Site 6 is approximately \$40,000.

Site 82

LTM at Site 82 initially consisted of collecting groundwater samples from 7 surficial, 6 UCH, and 7 LCH aquifer monitoring wells quarterly for VOCs, metals, TSS, and TDS analysis. Since 1999, 3 co-located surface water and sediment samples have been collected semi-annually for VOC analysis. Metals, TDS, and TSS were discontinued in 1997 (USMC, 1997); however, based on the results of an evaluation of metals in groundwater recommended during the 2010 FYR, potential unacceptable risks from exposure to metals in surficial groundwater to potential future residents were identified and metals were added back into LTM (Appendix A in CH2M HILL, 2014).

Based on supplemental investigations (summarized in CH2M HILL, 2014a), the LTM network was expanded and currently includes 13 surficial, 6 UCH, and 6 LCH aquifer monitoring wells, 10 recovery wells, and 3 co-located surface water and sediment sample locations. The LTM network will be updated as necessary based on the results of supplemental investigations that are currently underway. Surface water and sediment samples are collected semi-annually and are analyzed for VOCs and groundwater samples are collected annually and are analyzed for VOCs. Groundwater samples collected from surficial aquifer monitoring wells are analyzed for metals every five years (CH2M HILL, 2014b).

Sampling locations are shown on Figure 4-1. The annual cost of LTM at Site 82 is approximately \$45,000.

LUCs - OU 2

Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. On February 16, 2012, an unauthorized intrusion was observed at Site 6 when several Marines were excavating soil in order to fill sand bags within the intrusive activities control boundary. The area that was being excavated was the approximate location of the 2011 TCRA and the soil was likely the clean soil used as backfill. The bags were left onsite and screened using an organic vapor analyzer equipped with a photoionization detector (PID) as they were emptied; there were no detections. The Marines and their command were informed of the incident, restrictions in the area, and potential hazards they faced (USMC, 2012). A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions and no issues affecting protectiveness were observed (**Appendix B**).

All current groundwater plumes are maintained in Base GIS for use during construction or intrusive activity planning to prevent exposure to COCs. The LUCs are shown in **Figure 4-1** and summarized in **Table 4-4**.

TABLE 4-4
OU 2 Land Use Control Summary

LUC Boundary	Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date	
Non-Industrial Use Control Boundary (Soil)	206.75			
Intrusive Activities Control Boundary (Soil)	206.75	Il. 2002	F-l 2002	
Intrusive Activities Control Boundary (Groundwater)	99.4	July 2002	February 2002	
Aquifer Use Control Boundary (1,000 feet)	404.91			

ES120414012346RAL 4-5

4.5.2 Post-ROD Removal Actions and Pilot Studies

Site 6

Based on elevated and fluctuating concentrations of chlorobenzene reported in samples collected from IR06-GW16, additional investigations were conducted from 2002 to 2010 to assess the source and extent of contamination (CH2M HILL, 2010). From 2010 to 2011, a digital geophysical mapping and follow up test pit investigation were completed in the area upgradient of the well and drums containing chlorobenzene were uncovered (CH2M HILL, 2012). In May 2011, a TCRA was completed to remove the drums and grossly contaminated soils. Approximately 42 cubic yards of soil, buried debris, and two 55-gallon drums were removed and the site was restored with clean fill. Chlorobenzene concentrations in the confirmation samples from the removal area ranged from 170 to 2,600,000 μ g/kg, indicating that residual contamination is still present in soil. Follow up investigations were recommended to evaluate the extent of contamination in soil and revisit the remedy in place to evaluate protectiveness of human health and the environment (CH2M HILL, 2011).

Site 82

In December 2005, a pilot study was initiated to evaluate the use of ERD to remediate groundwater as an alternative to pump and treat. Groundwater recovery well IR06-DRW01 was selected as the injection well and 6 new monitoring wells were installed to evaluate the radius of influence and effectiveness of the pilot study. A total volume of 374 gallons of 42 percent lactate/emulsified oil blend was diluted to 1.3 percent in water and 28,140 gallons of solution were injected into the subsurface over 3 days. Degradation daughter products were detected in post-injection samples from three locations and changes in groundwater geochemistry (low dissolved oxygen [DO] and negative oxidation-reduction potential [ORP]) indicated a shift toward a more reducing environment for dechlorination.

Prior to injection, the recovery well was turned off for 12 months, during which time the concentration of TCE decreased from 9,200 to 160 μ g/L. This indicates that the recovery well was capturing impacted groundwater during operation but may not have been ideally located to remove the source of groundwater contamination (CH2M HILL, 2008).

4.5.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in **Table 4-5**. Additionally, supplemental investigations into potential sources and extent of contamination at OU 2 conducted since the 2010 FYR are summarized in **Table 4-6**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figures 4-3** (Site 6) and **4-4** (Site 82).

TABLE 4-5 2010 FYR OU 2 Recommendation/Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Cleanup levels have changed since the ROD	Update COCs and cleanup levels to reflect recent standards. (2012)	Cleanup levels have been updated to reflect current NCGWQS.
	Collect groundwater metals data for comparison to determine if site-related or attributable to background. If determined site-related, evaluate risks, add metals as COCs to LTM Program, evaluate LUCs, and prepare an ESD. (2013)	Completed in 2013. Groundwater samples were collected from monitoring wells within the LTM program and analyzed for total metals and an HHRS was conducted. Based on the results and comparison to historical data, the report recommended collecting groundwater samples for metals from surficial aquifer monitoring wells in the LTM program every 5 years and reevaluate metals as COCs during FYRs as trends are generated over time (CH2M HILL, 2015).
Groundwater extraction and treatment system may not be most cost- effective means of COC removal	Complete source area investigation. (2015)	Initial sampling was completed in 2013, follow-up delineation efforts are underway. Source investigations at Site 6 and 82 are summarized in Table 4-6 .
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	Make recommendations for repairs or changes in the treatment system to optimize mass removal. (2015)	The supplemental investigation is ongoing to further define the source areas and extent of contamination. Once completed, a detailed evaluation of the existing treatment system to optimize mass removal and potential
	Evaluate alternative treatment technologies. (2015)	alternative treatment technologies is planned (Table 4-6).

4-6 ES120414012346RAL

TABLE 4-5 2010 FYR OU 2 Recommendation/Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Potential for VI pathway	Evaluate and mitigate VI pathway during construction planning. (Ongoing)	There is no unacceptable risk from VI based on current land use. If buildings are planned for construction in the vicinity of the VOC groundwater plume, the potential for a VI pathway is evaluated and mitigated if needed. Base Master Planning maintains current groundwater plume data in the GIS, and all construction projects on-Base go through environmental review.

TABLE 4-6 Supplemental Investigations since the 2010 FYR

Investigation	Summary		
Chlorobenzene Summary Report (Site 6) (CH2M HILL, 2010)	During LTM, chlorobenzene was reported at elevated concentrations in one well (IR06-GW16) with a maximum concentration of 57,000 μ g/L in 1997. This concentration initiated an investigation into the source of chlorobenzene upgradient of the monitoring well. A geophysical survey, test pit excavation, monitoring well installation, and groundwater and soil sampling were completed to investigate the source of chlorobenzene in the central area between Lots 201 and 203. During vegetation clearing activities, material potentially presenting an explosive hazard (MPPEH) was discovered on the surface and in a burial pit.		
	The site entered the MMRP in May 2010 as Site UXO-22. Digital geophysical mapping was conducted and three large anomalies were identified for further investigation via test pit excavation.		
Phase II Lot 203 Environmental Condition of Property (ECP) for Property Real Estate DRMO Area	An ECP was performed to evaluate if potential environmental problems existed on the property before lease renewal by the Navy. Debris was found during test pitting activities and included batteries, metal and wooden debris, small containers, and 55-gallon drums.		
(Site 6) (Rhēa, 2010)	Six areas of concern were identified, and the report concluded that if no intrusive activities are conducted, Lot 203 is suitable for its intended future use (storage).		
Supplemental Source Investigation (Site 82) (Rhēa, 2011)	The supplemental source investigation was initiated to identify additional potential sources of CVOC contamination in groundwater at Site 82. During vegetation clearing activities, munitions debris (MD) was discovered. A geophysical survey, monitoring well installation, groundwater sampling, and test pitting were conducted. Soil samples collected from the test pits and groundwater samples were analyzed for VOCs. Cis-1,2-DCE, TCE, PCE, ethylbenzene, and PCA were detected at concentrations exceeding screening criteria.		
Site 6 Supplemental Investigation – Interim results (Site 6) (CH2M HILL, 2012)	As a follow-up to the recommendations of the Chlorobenzene Summary Report, test pitting to investigate the large geophysical anomalies and soil sampling were conducted. Twelve test pit excavations were completed and cultural debris, MD, drums, buckets, communication batteries, communication wires, and scrap metal were uncovered. At Test Pit 10, two drums were uncovered, resulting in elevated breathing zone measurements, and the maximum soil chlorobenzene concentration was 70,000,000 μ g/kg.		
	Additional monitoring wells were also installed and site-wide groundwater samples were collected to further investigate the extent of chlorobenzene in groundwater. Recommendations were to complete the delineation of chlorobenzene in groundwater, assess the distribution of chlorobenzene in vadose zone soil, and update LUCs, as necessary.		
PA/SI Report Site UXO-22 (Site 6 and 82) (CH2M HILL, 2013)	A field investigation was conducted to evaluate the presence and nature of munitions-related contamination. Field activities included soil and groundwater sampling for explosives residues and metals. Explosives residues and metals were detected in exceedance of screening criteria in subsurface soil, sediment, and groundwater samples.		
	Potential human health and ecological risks were identified from exposure to metals in soil, including surface soil in the ephemeral drainage. The metals exceedances are likely associated with the long-term use as a historical storage and waste disposal area rather than with the presence of MPPEH and munitions and explosives of concern (MEC). Therefore, it was recommended that metals in soil be addressed as part of IRP Sites 6 and 82.		
	Potential explosive hazards were identified based on the MEC and MPPEH found onsite during previous IRP investigations. An RI was recommended to further characterize the nature and extent of MEC. Additionally, a MEC surface clearance was recommended to minimize explosive risks from unintentional detonations, especially in the wooded areas and in the former DRMO area.		

ES120414012346RAL 4-7

TABLE 4-6
Supplemental Investigations since the 2010 FYR

Investigation	Summary

Lot 202 ECP for Property Real Estate DRMO Area (Site 6) (CH2M HILL, 2014c) An ECP was performed for Lot 202 to assess the lot's environmental condition in support of a potential interagency transfer of the property.

The study found that there were no known or documented instances where hazardous or petroleum substances were stored, disposed, or released on Lot 202. However, facility personnel suggested that buried debris may be present beneath Lot 202. A digital geophysical mapping survey and test pitting were conducted, and buried metallic and wooden debris was identified within the northern portion of Lot 202. Soil and groundwater samples were collected within Lot 202, and the concentrations do not pose an unacceptable human health risk.

Evaluation of chlorobenzene concentrations reported in well IR06-MW80 (adjacent to and east of Lot 202) shows that exposure to the groundwater from this well would result in unacceptable human health risks. Contamination from this well has the potential to migrate beneath the northern portion of Lot 202.

This ECP concluded that the property is suitable for transfer for the use as a controlled area storage yard.

Draft Supplemental Investigation Report (Sites 6 and 82) (CH2M HILL, 2015) In 2012 and 2013, a supplemental investigation was conducted to evaluate the potential for additional source material in soil and groundwater.

Site 6

- A PSG survey with confirmation soil sampling was completed in the 2011 TCRA area.
- New monitoring wells were installed downgradient and deeper than the existing well
 network and groundwater samples were collected from new and several existing wells for
 all VOCs

The results indicated that extent of the chlorobenzene plume was larger and deeper than previously thought and a CVOC plume was identified in the UCH and LCH aquifer (**Figures 4-4** and **Figure 4-5**, respectively). The fluctuations of VOCs in groundwater suggest that residual source material may exist. The extent of the chlorobenzene and CVOC plumes was not fully defined in the UCH and LCH aquifers.

Based on the results, additional horizontal and vertical delineation, CSM refinement, and a pilot study for chlorobenzene and chlorinated ethenes in groundwater were recommended.

Site 82

- A PSG survey with confirmation sampling was completed in suspected source areas.
- New monitoring wells were installed and groundwater samples were collected from new and several existing wells for analysis of VOCs, and select samples were analyzed for metals.
- Pore water samples were collected in the wetland south of Edwards Creek and within Edwards Creek for VOC analysis to assess the potential for discharge of contaminated groundwater to surface water.
- Co-located surface water and sediment samples were collected within Edwards Creek for VOC analysis to identify potential trends relating to contaminated media within the creek.

PSG and soil sampling data suggested sources are located in the northeastern-most area of the site outside of the estimated radius of influence of the groundwater extraction and treatment system. Groundwater, pore water, and surface water data indicated that VOCs are present in surficial and UCH groundwater up to the edge of the creek and VOC plumes are not fully delineated in the surficial, UCH, and LCH aquifers (Figures 4-6 and 4-7). VOCs were detected in the western portion of the site, which is not hydraulically downgradient from any of the known source areas, suggesting additional sources may exist.

Based on the results of these activities, additional horizontal and vertical delineation, groundwater modeling, CSM refinement, and optimization of the existing groundwater treatment system were recommended.

Field Activities for an Expanded Site Inspection (ESI) Site UXO-22

An ESI was initiated to further investigate the presence and nature of MEC and MPPEH and to evaluate the extent of the battery disposal area identified during the PA/SI. Field activities included DGM, an intrusive investigation, and collection of soil samples from beneath the battery disposal area, and surface clearing and soil screening within the former DRMO. Test pitting is ongoing in the battery disposal area.

4-8 ES120414012346RAL

4.6 Technical Assessment

Is the remedy functioning as designed?

No. Remedial actions were implemented at OU 2 to address RAOs based on the site conditions at the time of the ROD. However, new sources of VOCs that were not initially considered COCs have been identified, particularly chlorobenzene at Site 6, and 1,1,2,2-PCA at Site 82.

Site 82 Groundwater Extraction and Treatment System

The groundwater extraction and treatment system appears to be functioning as designed, although trends indicate that the monthly mass removal has decreased since the system start up. Potential source areas were identified during the Supplemental Investigation at locations vertically and laterally outside of the recovery well network (Figures 4-5 and 4-6, CH2M HILL, 2015). These sources will continue to contribute to the contaminant mass in groundwater which leads to potential discharge to Wallace Creek. A review of the existing recovery well network and potential for new recovery wells based on the results of supplemental investigations is recommended to maximize the removal efficiency of the groundwater extraction and treatment system.

Site 82 Long-term Monitoring and Land Use Controls

The LTM network was expanded to encompass the current understanding of the extent of COCs; LUCs will be updated once planned future investigations are completed at OU 2. Groundwater plumes are maintained in Base GIS and Master Planning to prevent exposure to COCs and maintain protectiveness while the LUCs are being reevaluated.

Site 6 Long-term Monitoring and Land Use Controls

The selected remedy at Site 6 was LTM. However, additional investigations are ongoing and indicate that continuing sources of chlorobenzene may be present at the site and the nature and extent of contamination is significantly different than the understanding at the time of the ROD (**Table 4-6**, **Figures 4-7** and **4-8**). The LTM network was expanded to encompass the current understanding of the extent of COCs; LUCs will be updated once supplemental investigations are completed at OU 2. Groundwater plumes are maintained in Base GIS and Master Planning to prevent exposure to COCs and maintain protectiveness while the LUCs are being re-evaluated.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The cleanup levels for groundwater were identified as the more conservative of the Federal MCLs or NCGWQS at the time the ROD (Baker, 1993b) was signed. Since that time, the standards for arsenic, barium, mercury, and vanadium are more conservative (**Table 4-1**). In addition, several VOC constituents that were detected above the MCLs/NCGWQS during LTM and supplemental investigations were added as COCs since the ROD (**Table 4-1**).

A review of current NCSWQS for streams classified as SB NSW (Primary Recreation, Salt Water; Nutrient Sensitive Waters) was conducted for comparison to the effluent standards in the ROD (**Table 4-3**). Several standards are more conservative than the effluent levels selected in the ROD and there are additional COCs since the time of the ROD.

The cleanup levels for pesticides, VOCs, and metals in soil were identified as risk-based levels calculated in the ROD (Baker, 1993b). The confirmation soil sample results documenting the contaminated soil removal indicate that the cleanup levels identified in the ROD were met (OHM, 1997). Although the recent USEPA industrial soil RSLs for DDT and arsenic are more conservative and confirmation soil data from one or more samples would exceed current DDT RSLs (maximum concentration 47,700 μ g/kg, OHM, 1997) (**Table 4-1**), the area was restored with clean fill following the removal action, and LUCs restricting intrusive activities and prohibiting non-industrial use remain in place and are protective.

The RAOs used at the time of selection are still valid. However, additional RAOs may be warranted to address the deeper contaminant mass, potential for contaminated groundwater to impact Wallace Creek, potential for explosive hazards from MEC, and the VI pathway.

ES120414012346RAL 4-9

Changes in Exposure Pathways: No. There is a potential for future VI exposure if land use changes or buildings are constructed within 100 feet of the VOC plumes at OU 2. Additionally, there is potential for contact with MEC within the boundary of Site UXO-22.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been changes to toxicity criteria for COCs (Table 2-1), groundwater cleanup levels were identified as the more conservative of the MCL and NCGWQS. Groundwater concentrations reported during LTM continue to exceed cleanup levels and LUCs will continue to be maintained to prevent exposure to contaminated soil and groundwater until reduction to levels that allow for UU/UE. Thus, toxicity changes for any of the chemicals detected at the site would not affect the protectiveness of the remedy.

Has any other information come to light that could question the protectiveness of the remedy?

Yes. Supplemental investigations have indicated that the groundwater COC plumes are deeper and more widespread and additional sources of COCs are present that were not identified at the time of the ROD. The VI pathway has the potential to become complete at OU 2 and potential explosive hazards were identified within the MMRP Site UXO-22 boundary. RAOs and LUCs should be added to include evaluating the potential for VI pathways if building or land use changes, as well as mitigation (if needed), and restriction of intrusive activities within the munitions response area with potential explosive safety hazards. Additionally, groundwater has not been sampled for 1,4-dioxane analysis and 1,1-DCE is a COC in groundwater at OU 2.

4.7 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 2 are summarized in Table 4-7.

TABLE 4-7
OU 2 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party	Oversight	Milestone	Affects Protectiveness (Y/N)	
	,	Responsible	Agency	Date -	Current	Future
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI for VI pathway and add an Industrial/Non- Industrial Use Control Boundary (VI)		USEPA/State	6/30/2016	N	Υ
Explosive hazards may be present within the boundary of UXO-22	n the include UXO-22 and add LUCs		USEPA/State	6/30/2016	N	Υ
Effluent standards for the treatment system were selected in 1993 based on State and Federal criteria that has since been updated	eatment system selected in 1993 on State and al criteria that has Re-evaluate effluent standards based on current State and Federal criteria		USEPA/State	12/30/2016	N	Υ
COCs were detected in surficial groundwater and porewater leading to Wallace Creek andicating a potential transport pathway from groundwater to surface water.		Navy/Base	USEPA/State	12/30/2016	N	Υ
Current extent of COCs in site media is not fully assessed at Sites 6 and B2 Complete assessment of the extent of COCs in site media Update groundwater LUCs as applicable		Navy/Base	USEPA/State	12/30/2016 12/30/2018	N	Y

4-10 ES120414012346RAL

TABLE 4-7
OU 2 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party	Oversight	Milestone	Affects Protectiveness (Y/N)	
		Responsible	Agency	Date -	Current	Future
An RSL was established for 1,4-dioxane and indicator constituents are present in groundwater at Sites 6 and 82	oxane and constituents in tin Collect groundwater samples for 1,4-dioxane to evaluate presence (absence)		USEPA/State	9/30/2018	N	Y
Existing treatment system does not encompass recently discovered source areas at Site 82 or groundwater contamination at Site 6	Evaluate expanding or modifying the existing treatment system at Site 82 and evaluate alternative treatment technologies at Site 6 and/or Site 82 to remediate source areas and minimize degradation of Wallace Creek and develop a		USEPA/State	12/30/2020	N	Υ

4.8 Statement of Protectiveness

The remedies for soil and groundwater at OU 2 are protective of human health and the environment in the short-term because LUCs are in place to prevent exposure. Soil LUCs are in place to restrict intrusive activities and non-industrial use and will be updated to include MEC. Groundwater LUCs are in place to prevent exposure to COCs and will be updated to reflect the current extent of COCs and to include mitigation of future VI pathways. To facilitate protectiveness, Base Master Planning maintains all current VOC plume data and MMRP site boundaries in the GIS and all construction projects go through environmental review.

In order for the remedy to be protective in the long-term, supplemental site investigations should be completed to define the extent of source material and COCs in groundwater. This information will then be used to update the RAOs and the site remediation strategy to address groundwater contamination and mitigate degradation of Wallace Creek.

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ES120414012346RAL 4-11

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4-12 ES120414012346RAL

TABLE 4-1
Cleanup Levels for OU 2 (Sites 6 and 82)
Five-Year Review

BA - di -	coc	ROD Cleanup Levels	Current C	Cleanup Level			
Media	COCs	(Baker, 1993)	Concentration	Reference			
	VOCs			•			
	1,1,2,2-Tetrachloroethane		0.2	NCGWQS			
	1,1-Dichloroethene		7	NCGWQS/MCL			
	1,2-Dichloroethane	0.38	0.4	NCGWQS			
	1,2-Dichloropropane		0.6	NCGWQS			
	1,4-Dichlorobenzene		6	NCGWQS			
	Benzene		1	NCGWQS			
	Chlorobenzene		50	NCGWQS			
	cis-1,2-Dichloroethene		70	NCGWQS/MCL			
	Ethylbenzene	29	600	NCGWQS			
	Tetrachloroethene	0.7	0.7	NCGWQS			
Groundwater (μg/L)	trans-1,2-Dichloroethene	70	100	NCGWQS/MCL			
	Trichloroethene	2.8	3	NCGWQS			
	Vinyl chloride	0.015	0.03	NCGWQS			
	Metals						
	Arsenic	50	10	NCGWQS/MCL			
	Barium	1,000	700	NCGWQS			
	Beryllium	4	4	MCL			
	Chromium	50	50	NCGWQS			
	Lead	15	15	NCGWQS/MCL			
	Manganese	50	50	NCGWQS			
	Mercury	1.1	1	NCGWQS			
	Vanadium	80	8.6	RSL-Tapwater			
	PCBs	10,000	10,000	Action Level for Low Occupancy Land Use (USEPA, 1990)			
	Pesticides						
	4,4-DDT	60,000	8,600	RSL-Industrial Soil			
C = !! (· · = /! · =)	VOCs						
Soil (μg/kg)	Benzene	5.4	5,100	RSL-Industrial Soil			
	Tetrachloroethene	10.5	39,000	RSL-Industrial Soil			
	Trichloroethene	32.2	19,000	RSL-Industrial Soil			
	Metals						
	Arsenic	23,000	3,000	RSL-Industrial Soil			
	Cadmium	39,000	98,000	RSL-Industrial Soil			
	Manganese	390,000	2,600,000	RSL-Industrial Soil			

Notes:

-- COC identified post-ROD during 2010 FYR based on LTM exceedances of 2010 cleanup levels Shading indicates cleanup levels achieved/remain protective per Closeout Report (OHM, 1997)

Cleanup Level Reference Dates:

MCL (May 2009) NCGWQS (April 2013)

RSL (November 2014)

TABLE 4-2
OU 2 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
		Potential unacceptable risks to		Treat or remove contaminated soil.	Soil Removal	Excavation and offsite disposal of soil [and debris] from areas of concern to meet industrial levels.	
	Soil	current Base personnel and future residents due to exposure to pesticides and PCBs in soil.		Prevent current and future exposure to contaminated soil.	LUCs	Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	Industrial Land Use
		Potential unacceptable risks to current Base personnel and future residents due to exposure to metals and VOCs in groundwater.		Remediate groundwater for future use of the aquifer.	LTM	Groundwater LTM to monitor natural attenuation of COCs. Will be continued until all groundwater COCs are at or below cleanup levels for 4 consecutive monitoring events.	
6	Groundwater		Industrial/Vacant/ Storage	Prevent current and future exposure to contaminated groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	UU/UE
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent future exposure to COCs in indoor air via the VI pathway.		Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
	MEC/MPPEH	Potential explosive hazard from contact with MEC/MPPEH within the Site UXO-22 boundary.		Reduce or prevent the potential for direct physical contact with MEC/MPPEH.	LUCs	Maintain intrusive activities control for MEC and conduct quarterly monitoring.	Restricted Use
		Potential unacceptable to current Base personnel and future site residents due to exposure to metals and VOCs in soil.		Treat and remove contaminated soil.	Soil Removal	Excavation and offsite disposal of soil [and debris] from areas of concern to meet industrial levels.	
82	Soil			rreat and remove contaminated soll.	SVE	SVE to remove VOCs in soil. System operated for 6 months when soil cleanup levels were met.	Industrial Land Use
				Prevent current and future exposure to contaminated soil.	LUCs	Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	

TABLE 4-2
OU 2 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
	Potential unacceptable to current Base personnel and future site residents due to exposure to metals and VOCs in groundwater.		Remediate groundwater for future use of	Groundwater	Operate until after groundwater COCs are at or below respective cleanup levels. Perform routine maintenance. Monitor VOC mass removal in conjunction with LTM data to evaluate system effectiveness.		
		current Base personnel and future site residents due to exposure to metals and VOCs	cceptable to personnel and sidents due to netals and VOCs er. Industrial/Vacant/ Storage cceptable risks to ersonnel and n exposure to	the aquifer.	LTM	Groundwater and surface water LTM to monitor treatment system performance, migration, and COC concentration trends over time until after groundwater COCs are at or below cleanup levels for 4 consecutive monitoring events.	UU/UE
82 (con't)				Prevent current and future exposure to contaminated groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent future exposure to COCs in indoor air via the VI pathway.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
	MEC/MPPEH	Potential explosive hazard from contact with MEC/MPPEH within the Site UXO-22 boundary.	Reduce or prevent the potential for direct physical contact with MEC/MPPEH.	LUCs	Maintain intrusive activities control for MEC and conduct quarterly monitoring.	Restricted Use	

Notes

Shading indicates Risks/Basis of Action resulting from changing site conditions, exposure pathways, or assumptions that were not present at the time of the ROD. The proposed RAO, Remedy Component, and Performance Metric are included.

MEC - munitions and explosives of concern

MPPEH - material potential presenting an explosive hazard

TABLE 4-3
Site 82 Groundwater Treatment Plant Effluent Levels
Five-Year Review

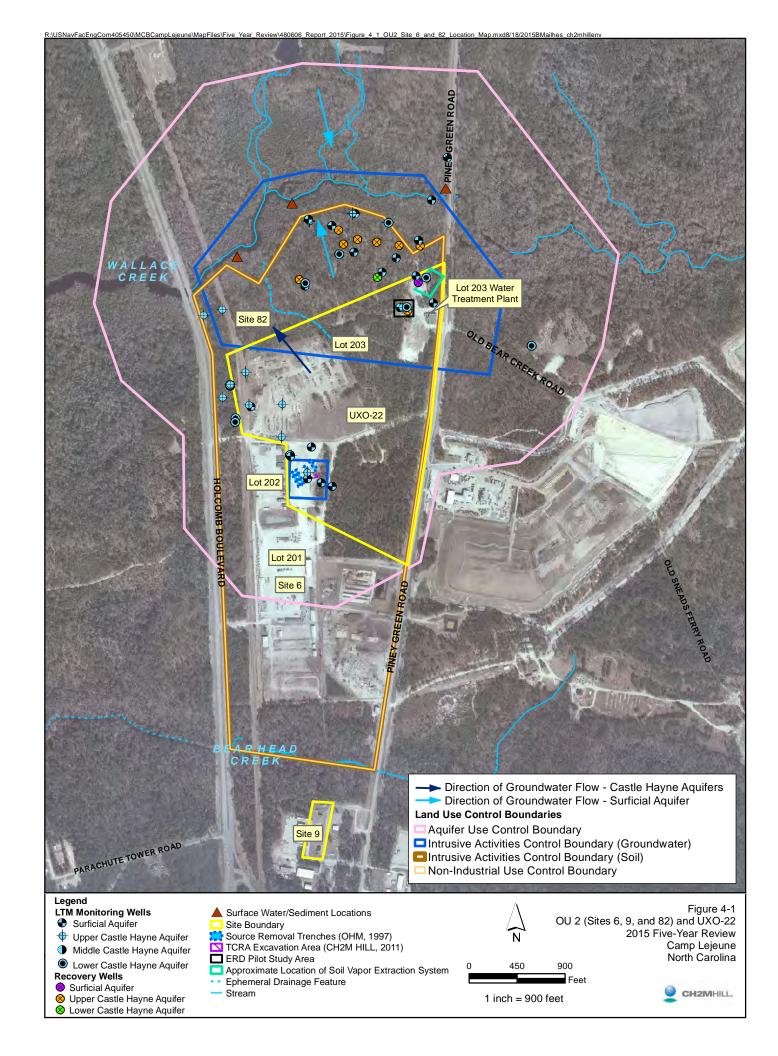
COCs	ROD Effluent Levels (Baker, 1993)	Source of ROD Effluent Levels	Current NCSWQS	Source of Current NCSWQS ¹
VOCs (μg/L)				
1,1,2,2-Tetrachloroethane			4	Human Health (HH)
1,1-Dichloroethene			7,100	НН
1,2-Dichloroethane	113,000	Federal Ambient Water Quality Criteria for Protection of Marine Life (acute)	37	НН
1,2-Dichloropropane			15	НН
1,4-Dichlorobenzene			190	НН
Benzene			51	НН
Chlorobenzene			1,600	НН
cis-1,2-Dichloroethene			720	НН
Ethylbenzene	430	Federal Ambient Water Quality Criteria for Protection of Marine Life (acute)	25	Saltwater Aquatic Life
Tetrachloroethene	0.8	North Carolina Ambient Water Criteria for Freshwater Classes (WS Classes)	3.3	нн
trans-1,2-Dichloroethene	100	Federal MCL	10,000	НН
Trichloroethene	92.4	North Carolina Ambient Water Criteria for Tidal Saltwater (Human Health)	30	нн
Vinyl chloride	525	North Carolina Ambient Water Criteria for Tidal Saltwater (Human Health)	2.4	нн
Metals (μg/L)	•			•
Arsenic	50	North Carolina Ambient Water Criteria for Tidal Saltwater (Human Health)	10	НН
Barium	1,000	North Carolina Ambient Water Criteria for Freshwater Classes (WS Classes)	200	НН
Beryllium	0.117	North Carolina Ambient Water Criteria for Tidal Saltwater (Human Health)	6.5	Freshwater Aquatic Life
Chromium	20	North Carolina Ambient Water Criteria for Tidal Saltwater (Aquatic Life)	20	Saltwater Aquatic Life
Lead	25	North Carolina Ambient Water Criteria for Tidal Saltwater (Aquatic Life)	25	Saltwater Aquatic Life
Manganese	50	North Carolina Ambient Water Criteria for Freshwater Classes (WS Classes)	200	
Mercury	0.025	North Carolina Ambient Water Criteria for Tidal Saltwater (Aquatic Life)	0.0025	Saltwater Aquatic Life
Vanadium	NS	No standard established	NS	No standard established

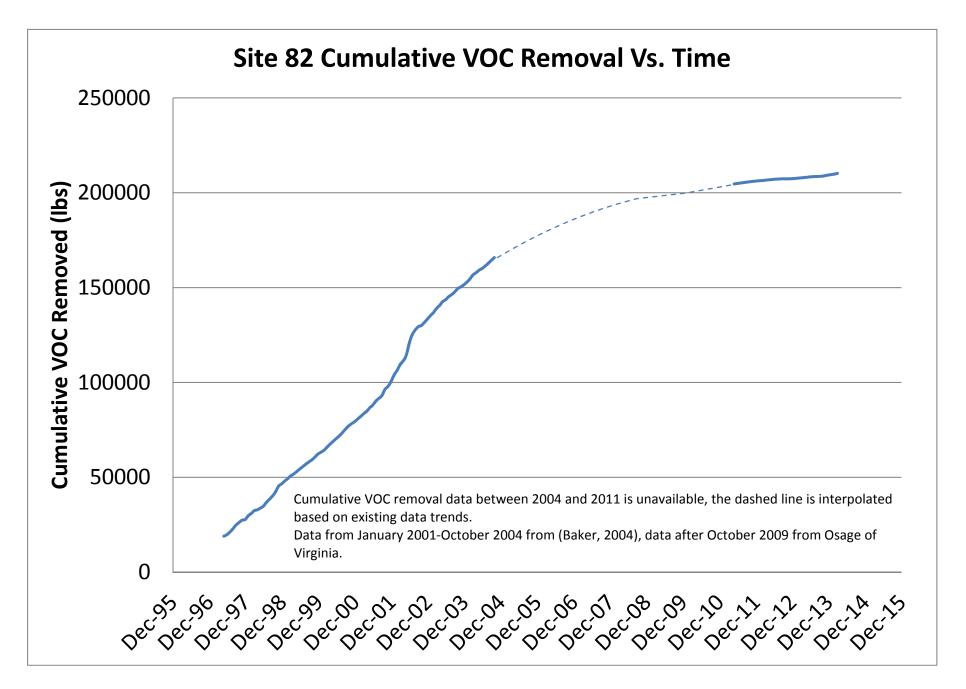
Notes:

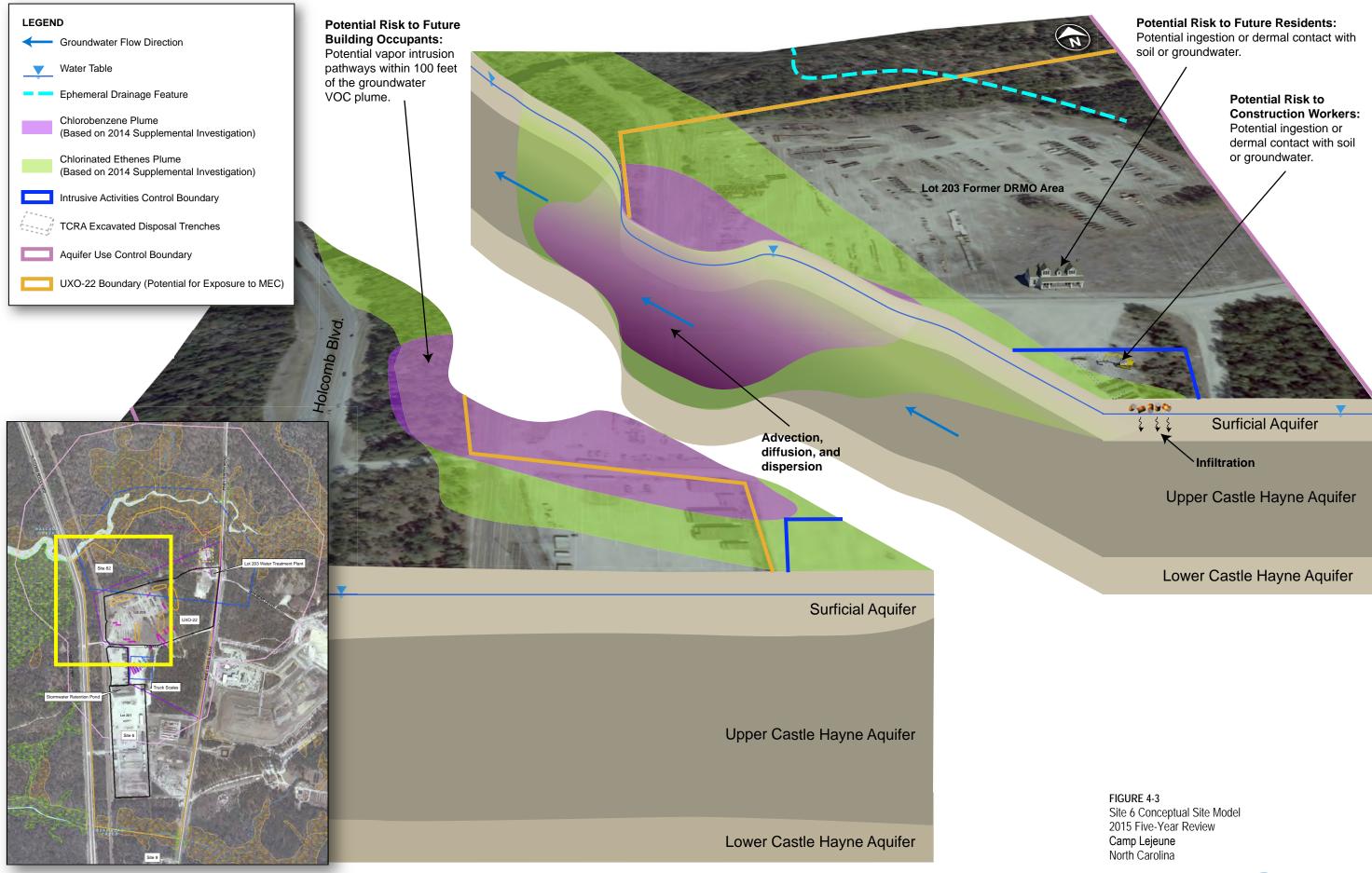
NS - No standard established

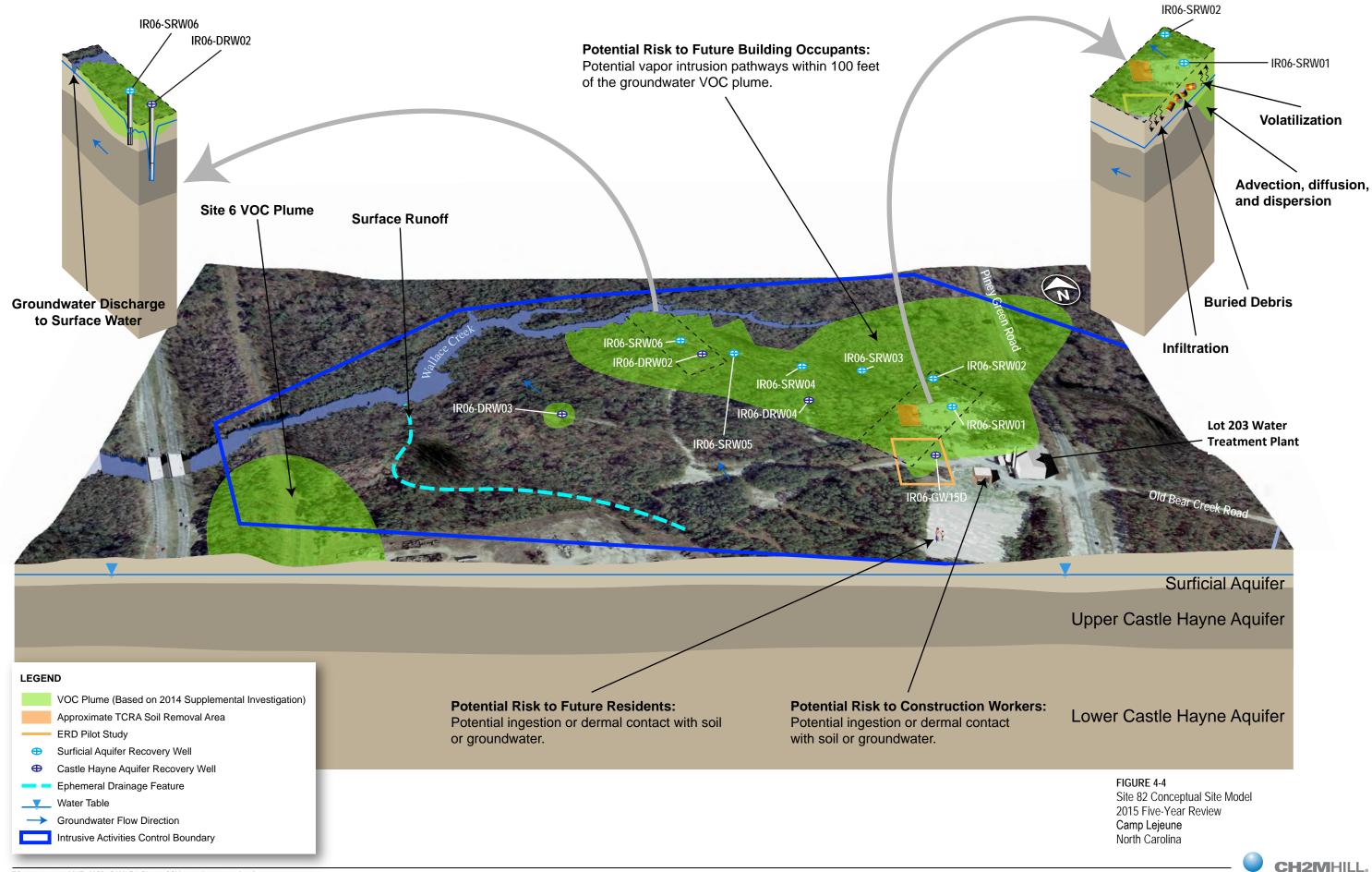
⁻⁻ COC identified post-ROD based on LTM exceedances of cleanup levels

¹Wallace Creek is classified as Primary Recreation, Salt Water; Nutrient Sensitive Waters (SB; NSW). The applicable NCSWQS was selected as the most stringent between saltwater aquatic life or human health criteria from the North Carolina and EPA Criteria table (May 2013). If neither standard is available then the most stringent available standard was used.



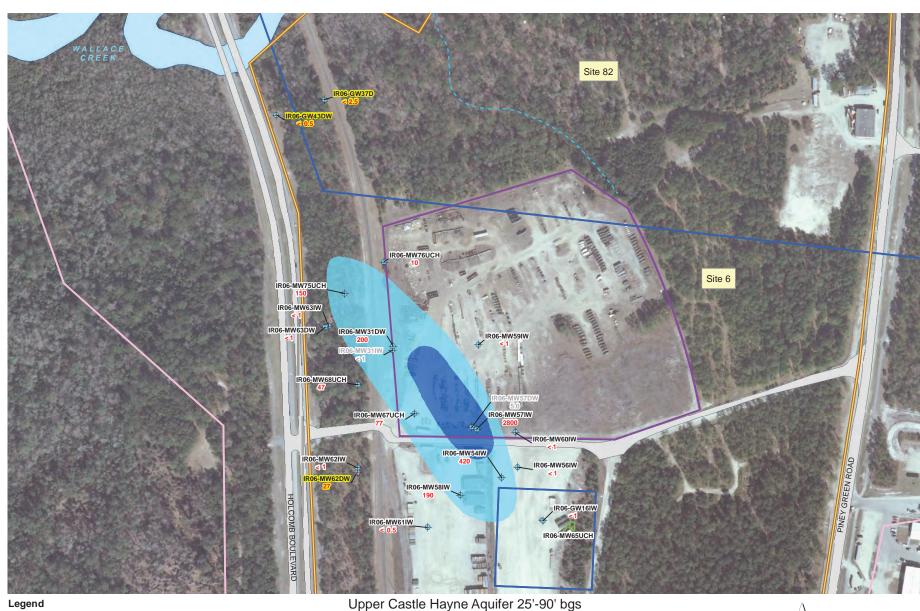








Surficial Aquifer 0'-25' bgs



Legend

- Monitoring Well Surficial Aquifer
 Monitoring Well Not Sampled Surficial Aquifer
 Monitoring Well Upper Castle Hayne Aquifer
 Ephemeral Drainage Feature

- Former DRMO Surface Water

Chlorobenzene (dashed where inferred)

> 50 µg/L

> 500 µg/L

Land Use Control Boundaries

- Aquifer Use Control Boundary
 Intrusive Activities Control Boundary (Groundwater)
 Intrusive Activities Control Boundary (Soil)

Non-Industrial Use Control Boundary TCRA Excavation Area

Concentrations shown in micrograms per liter ($\mu g/L$) Samples were collected in October 2012

ND - not detected NCGWQS for chlorobenzene = $50 \mu g/L$

NCGWQS - North Carolina Groundwater Quality Standards IR06-MW31IW and IR06-MW57DW are screened at a different interval within aquifer and were not used to develop isoconcentrations contours

Highlighted wells sampled under previous investigation

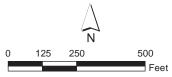


FIGURE 4-5 Supplemental Investigation Site 6 - Chlorobenzene in Groundwater 2015 Five-Year Review Camp Lejeune North Carolina





Surficial Aquifer 0'-25' bgs



Upper Castle Hayne Aquifer 25'-90' bgs



Legend

- Monitoring Well Surficial Aquifer
 Monitoring Well Surficial Aquifer Not Sampled
 Monitoring Well Upper Castle Hayne Aquifer
- Monitoring Well Lower Castle Hayne Aquifer
 Monitoring Well Lower Castle Hayne Aquifer Not Sampled
 Ephemeral Drainage Feature

Surface Water

Exceedance of one or more NCGWQS

Former DRMO

Chlorinated Ethenes (dashed where inferred) Land Use Control Boundaries Aquifer Use Control Boundary Intrusive Activities Control Boundary (Groundwater) Intrusive Activities Control Boundary (Soil) Non-Industrial Use Control Boundary > 1 μg/L > 10 μg/L > 100 μg/L TCRA Excavation Area

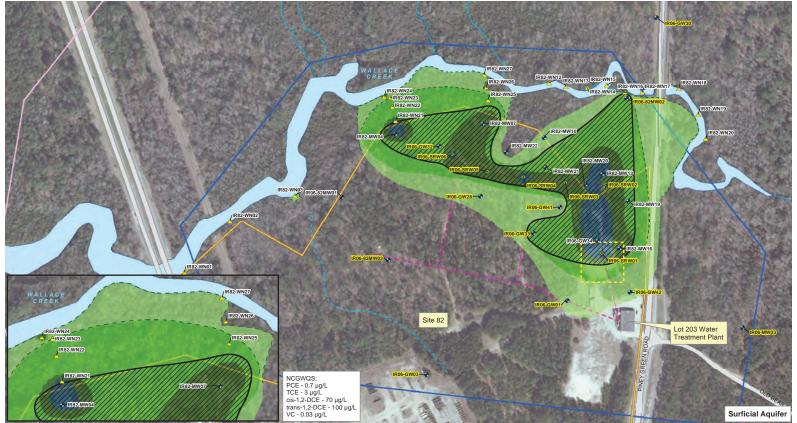
Lower Castle Hayne Aquifer 90'-250' bgs

Notes: NCGWQS - North Carolina Groundwater Quality Standard PCE - tetrachloroethene TCE - trichloroethene DCE - dichloroethene VC - vinyl chloride IR06-MW31IW, IR06-MW57IW, and IR06-MW63IW, IR06-MW70LCH, and IR06-MW74LCH are screened at a different interval within aquifer and were not used to develop isoconcentration contours

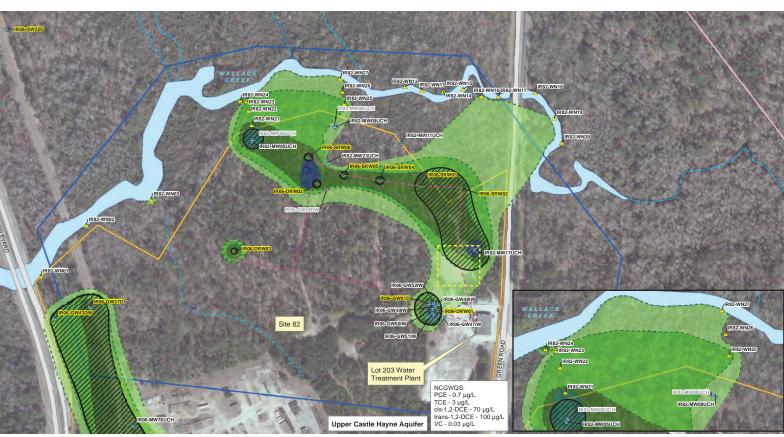
N 250 500

FIGURE 4-6 Supplemental Investigation Site 6 – Chlorinated Ethenes in Groundwater 2015 Five-Year Review Camp Lejeune North Carolina





Surficial Aquifer 0'-25' bgs



Upper Castle Hayne Aquifer 25'-90' bgs





Monitoring Well - Upper Castle Hayne Aquifer
Monitoring Well - Upper Castle Hayne Aquifer - Not Sampled

Monitoring Well - Lower Castle Hayne Aquifer

Exceedance of one or more NCGWQS

Northern Laydown Yard
Chlorinated Ethenes (dashed where inferred)

> 1 µg/L > 10 µg/L > 100 µg/L > 1,000 µg/L > 1,000 µg/L

Monitoring Well - Lower Castle Hayne Aquifer - Not Sampled
 Groundwater Treatment System Piping
 Exceedance of one or more NCGWQS
 Ephemeral Drainage Feature

Stream Surface Water
Land Use Control Boundaries

Aquifer Use Control Boundary Intrusive Activities Control Boundary (Groundwater) Intrusive Activities Control Boundary (Soil) Non-Industrial Use Control Boundary

Lower Castle Hayne Aquifer 90'-310' bgs

Notes:
NCGWQS - North Carolina Groundwater Quality Standard
PCE - tetrachloroethene
TCE - trichloroethene
DCE - dichloroethene
VC - vinyl chloride
Highlighted wells sampled during previous investigation

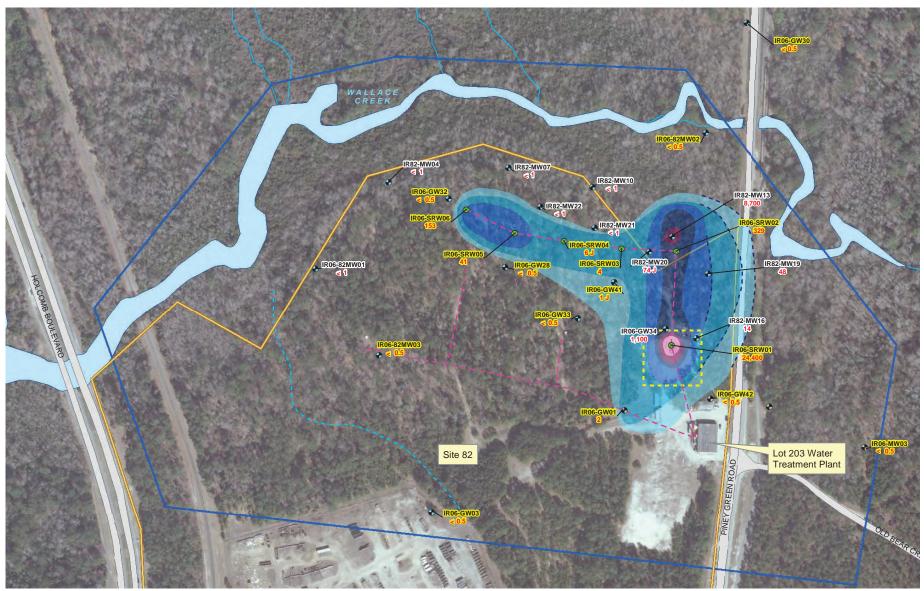
IR82-MW6UCH and IR82-MW8UCH are screened at a different interval within aquifer and were not used to develop isoconcentration contours.

Pore water samples were added for the purpose of completeness and to allow for depiction of the plume migrating to Wallace Creek. While the plume is inferred where detections in pore water were observed, migration at the groundwater to surface water interface is complex, and concentration data were not always consistent with expected distribution relative to adjacent groundwater. Consequently, the plumes are dashed in the vicinity of Wallace Creek.

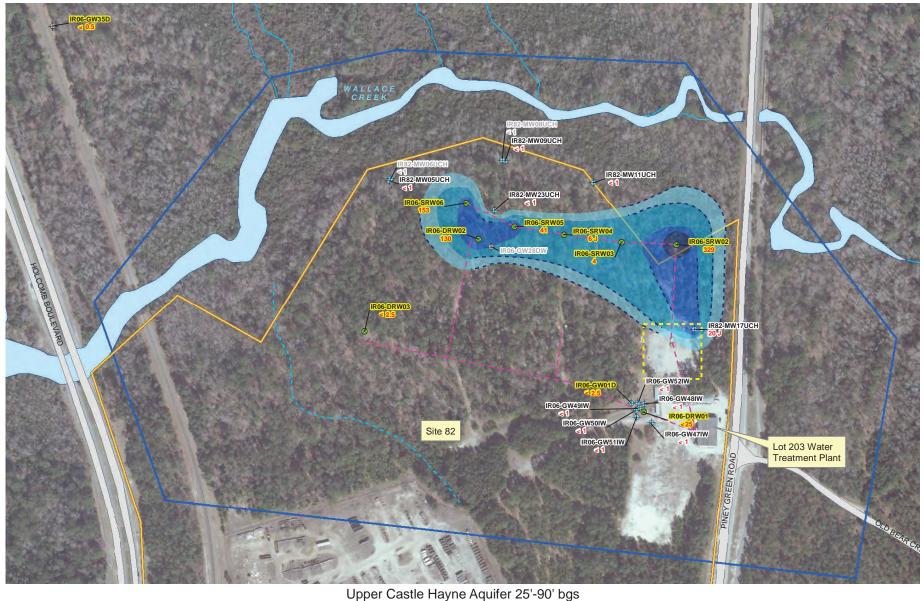


FIGURE 4-7 Supplemental Investigation Site 82- Chlorinated Ethenes in Groundwater 2015 Five-Year Review Camp Lejeune North Carolina





Surficial Aquifer 0'-25' bgs



Legend

Monitoring Well - Surficial Aquifer

Monitoring Well - Surficial Aquifer - Not Sampled
Monitoring Well - Upper Castle Hayne Aquifer
Monitoring Well - Upper Castle Hayne Aquifer - Not Sampled
Recovery Well
Land Use Control Boundaries

Aquifer Use Control Boundary

Intrusive Activities Control Boundary (Groundwater) Intrusive Activities Control Boundary (Soil)
Non-Industrial Use Control Boundary

Ephemeral Drainage Feature

- - Groundwater Treatment System Piping Stream

Northern Laydown Yard Surface Water

1,1,2,2-PCA (dashed where inferred)

> 0.2 µg/L > 2 µg/L > 20 µg/L

> 200 µg/L > 2,000 µg/L > 20,000 µg/L

Notes:
Concentrations shown in micrograms per liter (µg/L)
Samples were collected in October 2012
NCGWQS - North Carolina Groundwater Quality Standard
J - Analyte present, value may or may not be accurate or precise PCA - Tetrachloroethane

IR82-MW6UCH and IR82-MW8UCH are screened at a different

interval within aquifer and were not used to develop isoconcentration contours

Highlighted wells sampled during previous investigation

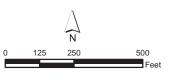


FIGURE 4-8

Supplemental Investigation Site 82 – 1,1,2,2-Tetrachloroethane in Groundwater 2015 Five-Year Review Camp Lejeune North Carolina



Operable Unit 4 (Sites 41 and 74)

5.1 Site History and Background

OU 4 is within the Mainside area of the Base and the Marine Corps Air Station (MCAS) New River (**Figure 1-2**). OU 4 consists of two sites (Sites 41 and 74) that have been grouped together based on the unique characteristic of suspected waste (chemical agent).

Site 41 — Camp Geiger Dump near Former Trailer Park is approximately 37 acres (Figure 5-1). Construction debris, petroleum, oil, and lubricants (POL) compounds, solvents, batteries, ordnance, chemical training agents, and mirex (a pesticide), were reportedly disposed at Site 41. The debris was reportedly burned, covered with soil, and then graded. The dump area contains an estimated 110,000 cubic yards of waste. The amount of solvents and oil disposed was estimated to be between 10,000 and 15,000 gallons. The quantity of mirex was estimated at several tons.

Site 74 — Mess Hall Grease Dump is approximately 24 acres and was used from the early 1950s through the early 1960s (Figure 5-2). Grease from the mess hall at Site 74 was reportedly disposed of in trenches.

1983	•IAS	
1984- 1987	Confirmation Study	
1993- 1995	•RI/FS	
1995	•PRAP and ROD	
1997- 1998	•LTM (Site 74)	
1997- 2004	•LTM (Site 41)	
2001	•RIP (LUCs)	
2002	•LUCs Updated	
2006	•RACR and Closeout	
2001- 2002	•Henderson Pond Investigation (Site 74)	

It was also reported that drums containing PCBs and pesticide-soaked bags were buried near the grease pit. Estimates of quantities include 1,100 gallons of PCB oil, 50 to 500 gallons of DDT, and 2,200 gallons of drummed pesticides. One internal memorandum reports chemical agents in the form of test kits were reportedly disposed of at Site 74. A former Pest Control Area was also reportedly located in the southeastern portion of the Site.

5.2 Site Characterization

The findings from various investigations at OU 4 that are pertinent to the FYR are summarized in this section.

5.2.1 Physical Characteristics

- Surface Features Both sites within OU 4 are densely vegetated. Site 41 is located on a hill and construction and demolition debris is present on the ground surface. Site surface water drains to Tank Creek to the south and an unnamed tributary to the north. Two seeps are located along the northern and eastern boundaries of the disposal area. Site 74 is primarily flat. Henderson and Hickory Ponds are approximately one quarter mile to the south/southeast of the former pesticide storage/handling area.
- **Geology and Hydrogeology** OU 4 is underlain by silty sand with discontinuous layers of sand, clayey sand, sandy clay, silt, and clay. The upper unit of the Castle Hayne aquifer, consisting of shelly sand, was encountered beneath the silty sands. Surficial aquifer groundwater flows south-southeast at Site 41 and east-northeast at Site 74.

5.2.2 Land Use

- Current Land Use Both sites are currently not in use and access is restricted by chain-link perimeter fencing.
 An access road leading to the Henderson Pond recreation area runs through the center of Site 74 and fencing was installed along both sides of the access road.
- Future Land Use There are no anticipated changes in land use.

ES120414012346RAL 5-1

5.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessment results relevant at the time of the ROD. Details are located in the OU 4 RI report (Baker, 1995a) and the OU 4 ROD (Baker, 1995b).

Site 41

- O&G and phenols were detected in groundwater, surface water, and sediment. VOCs, pesticides, and metals
 were detected in surficial aquifer groundwater and seeps, and PAH compounds were detected in surface soils.
- An HHRA and ERA were completed for Site 41 as part of the RI. Potential human health risks were identified
 for future residents and construction workers due to exposure to metals in groundwater (residents only) and
 chemical agent in soil. Potential ecological risks were identified due to exposure to metals in the seeps;
 however, seeps are not considered ecological habitats and surface water and sediment concentrations did not
 present unacceptable risks; therefore, no unacceptable ecological risks were identified (Baker, 1995a).

Site 74

- Pesticides and metals were detected in soil and groundwater at the site.
- An HHRA and ERA were completed at Site 74 as part of the RI. Potential human health risks were identified for
 future residents and construction workers due to metals and pesticides in groundwater (residents only) and
 chemical agent in soil. No unacceptable ecological risks were identified (Baker, 1995a).

5.3 Remedial Actions Objectives

The ROD addressing soil and groundwater at OU 4 was signed in December 1995 (Baker 1995b). The RAOs identified for OU 4 are:

- Prevent future potential exposure to contaminated soils and former disposal area materials.
- Prevent future potential exposure to contaminated groundwater.

The cleanup levels for OU 4 are presented in **Table 5-1**.

5.4 Remedial Actions

The OU 4 RA components and expected outcomes are summarized in **Table 5-2**. The RA for OU 4 includes the following major components:

- LTM of groundwater to assess changes in COC concentration and extent.
- LTM of surface water and sediment to confirm that no unacceptable contamination migration is occurring.
- LUC implementation for soil and groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the surficial aquifer within 500 feet of the estimated impacted groundwater extent.
 - Restrict intrusive activities within the vicinity of the estimated impacted groundwater and soil extent.
 - Prohibit non-industrial land use within the extent of the former soil removal which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.

5.4.1 Remedy Implementation

LTM was initiated at OU 4 in 1997. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002). The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

5-2 ES120414012346RAL

5.4.2 Remedy Operation and Maintenance

Long-term Monitoring

The LTM Program at Site 41 included sampling of five monitoring wells and eight surface water and sediment locations twice a year for analysis of VOCs, metals, TDS, and TSS. In 2004, groundwater samples were collected for explosives residues, chemical agent constituents, and breakdown products, and there were no detections. In 2005, LTM was discontinued at Site 41 because the groundwater cleanup levels were achieved and surface water and sediment data indicated that site COCs were not migrating offsite (**Table 5-1**). No cleanup levels were established for surface water and sediment. However, VOCs were not detected in surface water or sediment during LTM and metals did not exceed comparison criteria during the later rounds of LTM (CH2M HILL, 2006).

The LTM Program at Site 74 included sampling of four monitoring wells twice a year for metals. In 1998, LTM at Site 74 was discontinued because detected metal concentrations were indicative of naturally occurring metals in the presence of acidic soils (CH2M HILL/Baker, 2001).

Land Use Controls

A fence was installed around the perimeter of the site in 2008 to restrict access. Additional fencing was installed in 2011 along both sides of the access road leading to Henderson Pond. The LUCs are shown on **Figures 5-1** and **5-2** and summarized in **Table 5-3**. LUCs shall be maintained based on the presence of waste and potential for chemical agents. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. In April 2011, an unauthorized intrusion was observed when utility manholes were installed within the Site 74 boundary; they were promptly relocated (**Appendix A**). A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions and no intrusions were identified (**Appendix B**).

TABLE 5-3
OU 4 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Site 41			
Non-Industrial Use Control Boundary	36.6		
Intrusive Activities Control Boundary (Soil)	36.6	Il., 2002	Fabruary 2002
Intrusive Activities Control Boundary (Groundwater)	16.4	July 2002	February 2002
Aquifer Use Control Boundary (500 feet)	86.4		
Access Control Boundary	30		
Site 74			
Non-Industrial Use Control Boundary (Soil)	23.8		
Intrusive Activities Control Boundary (Soil)	23.8	July 2002	F-h 2002
Intrusive Activities Control Boundary (Groundwater)	13.9	July 2002	February 2002
Aquifer Use Control Boundary (500 feet)	71.2		
Access Control Boundary (fence along entry to recreational area)	20.5		

5.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 5-4.

ES120414012346RAL 5-3

TABLE 5-4
2010 FYR OU 4 Recommendations/Follow-up Actions

Issues	Recommendations (Milestones)	Date Complete/Current Status
Monitoring wells remain in place	Abandon existing monitoring wells in accordance with NC Regulations. (2012)	Completed in 2011. The monitoring wells at Site 41 were abandoned. A visual inspection of the site confirmed that no monitoring wells were present at Site 74.

Henderson/Hickory Pond Investigation

Given the intended use of expanding the area for recreation, fencing was installed in 2011 along both sides of the access road leading to Henderson and Hickory Ponds. Additionally, 0.5 to 1 foot of gravel was placed over the roadway for protection of construction workers. To evaluate whether the environmental conditions potentially pose unacceptable risks to human and ecological receptors, an investigation was completed at Henderson and Hickory Ponds in 2011 and 2012 (CH2M HILL, 2012 and 2013). Soil, sediment, and surface water samples were collected in November 2011. Potential unacceptable risks (human and ecological) were identified based on concentrations of SVOCs, pesticides, metals, and one PCB (Aroclor-1260) in soil and sediment. As a result, additional soil, sediment, and fish tissue samples were collected in 2012.

The HHRA and ERA indicated that direct exposure to soil, surface water, and sediment in the investigation area would not result in unacceptable risks to human health and the environment. Fish populations appeared to be abundant and overall risk to ecological receptors in the pond was considered low. Carcinogenic risks associated with ingestion of fish from either Henderson or Hickory Pond by adults, children, and lifetime anglers are within acceptable USEPA levels. However, ingestion of fish from Henderson or Hickory Pond would result in non-carcinogenic hazards above acceptable USEPA levels for adults and children. The hazard is associated with non-dioxin-like PCBs for Henderson Pond and mercury for Hickory Pond. However, the risk calculations are conservative and assume that only fish from either Henderson or Hickory Pond is ingested, and not from other water bodies; Henderson Pond and Hickory Pond are stocked with fish brought in from off-Base locations where there could be potential sources. Therefore, consistent with advisories already in place for NC, anglers are notified of potential risk from consumption of fish through flyers posted at the Game Warden's Office and signage along the ponds.

5.5 Technical Assessment

Is the remedy functioning as designed?

Yes. LUCs remain in place to restrict non-industrial land use, intrusive activities in waste, groundwater, and soil, and aquifer use. Access is also restricted by chain-link perimeter fencing.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The cleanup levels for groundwater were identified as the more conservative of the Federal MCLs or NCGWQS at the time the ROD was signed. Since that time, the standards for arsenic and chromium have been updated to more conservative values that remain the same since the 2010 FYR as listed in **Table 5-1**. LTM had been discontinued previously based on no exceedances of the cleanup levels identified in the ROD. However, the maximum concentration of arsenic and chromium listed in the closeout report (CH2M HILL, 2006) were 8.6 and 2 μ g/L, respectively, which are below the updated standard (10 μ g/L).

Changes in Exposure Pathways: Exposure pathways at Site 74 have changed because Henderson Pond was designated as a recreational area with access through Site 74. A gravel road and new fencing were constructed to prevent access to the site.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs (**Table 2-1**), the remedy to maintain LUCs restricts unauthorized activities which may result in exposure to buried materials and/or groundwater. Thus, toxicity changes would not affect the protectiveness of

5-4 ES120414012346RAL

the remedy. Additionally, the more conservative of the Federal MCLs or NCGWQS was identified as the groundwater cleanup level, and these values have not changed since the 2010 FYR.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

5.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 4 during this review.

5.7 Statement of Protectiveness

The remedy at OU 4 is protective of human health and the environment. Perimeter fencing restricts access to the waste areas at Sites 41 and 74. The LUCs to restrict intrusive activities, aquifer use, and non-industrial use at the sites are protective because exposure pathways to waste that could result in unacceptable risks are being controlled. Groundwater LTM is determined complete because the detected concentrations from the final four rounds of LTM were below the cleanup levels and this remains protective because the detected concentrations were below the current standards and there is no current or potential future exposure. Surface water and sediment LTM at Site 41 is determined complete because COCs in groundwater are below current standards, and potential future discharge of groundwater to surface water will not be impacted.

5.8 References

Baker. 1995a. Remedial Investigation Report, Operable Unit No. 4 (Sites 41 and 74). Marine Corps Base Camp Lejeune, North Carolina.

Baker. 1995b. Record of Decision for Operable Unit No. 4 (Sites 41 and 74), Marine Corps Base Lejeune, North Carolina. October.

Baker. 2002. Land Use Control Implementation Plans. Marine Corps Base Camp Lejeune, North Carolina. July.

CH2M HILL/Baker. 2001. Long-Term Monitoring Report, OU No.4, Site 74. Marine Corps Base Camp Lejeune, North Carolina. August

CH2M HILL. 2006. Closeout Report, Operable Unit No. 4 – Sites 41 and 74. Marine Corps Base Camp Lejeune, North Carolina. July.

CH2M HILL. 2010. Five-Year Review. Marine Corps Base Camp Lejeune, North Carolina. August.

CH2M HILL. 2012. *Technical Memorandum, Confirmatory Sampling Investigation, IR Site 74 – Henderson Pond, Marine Corps Base Camp Lejeune, North Carolina*. February.

CH2M HILL. 2013. Henderson Pond/Hickory Pond Investigation Report. Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina. January.

ES120414012346RAL 5-5

TABLE 5-1

Cleanup Levels for OU 4 (Sites 41 and 74)

2015 Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels	Current Cleanup Level	
ivieuia	COCS	(Baker, 1995)	Concentration	Reference
	Arsenic	50	10	NCGWQS/MCL
	Beryllium	4	4	MCL
Groundwater (μg/L)	Cadmium	5	2	NCGWQS
Groundwater (μg/L)	Chromium	50	10	NCGWQS
	Lead	15	15	NCGWQS/MCL
	Nickel	100	100	NCGWQS

Notes:

Shading indicates cleanup levels achieved per Closeout Report (CH2M HILL, 2006)

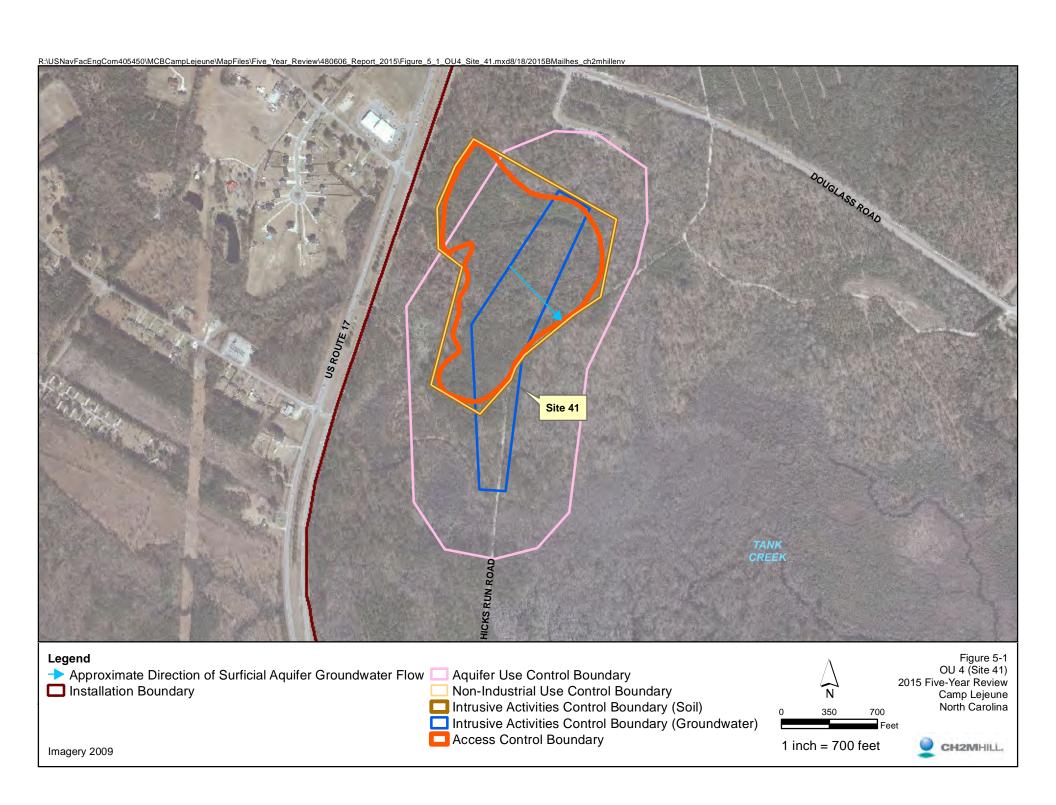
Cleanup Level Reference Dates:

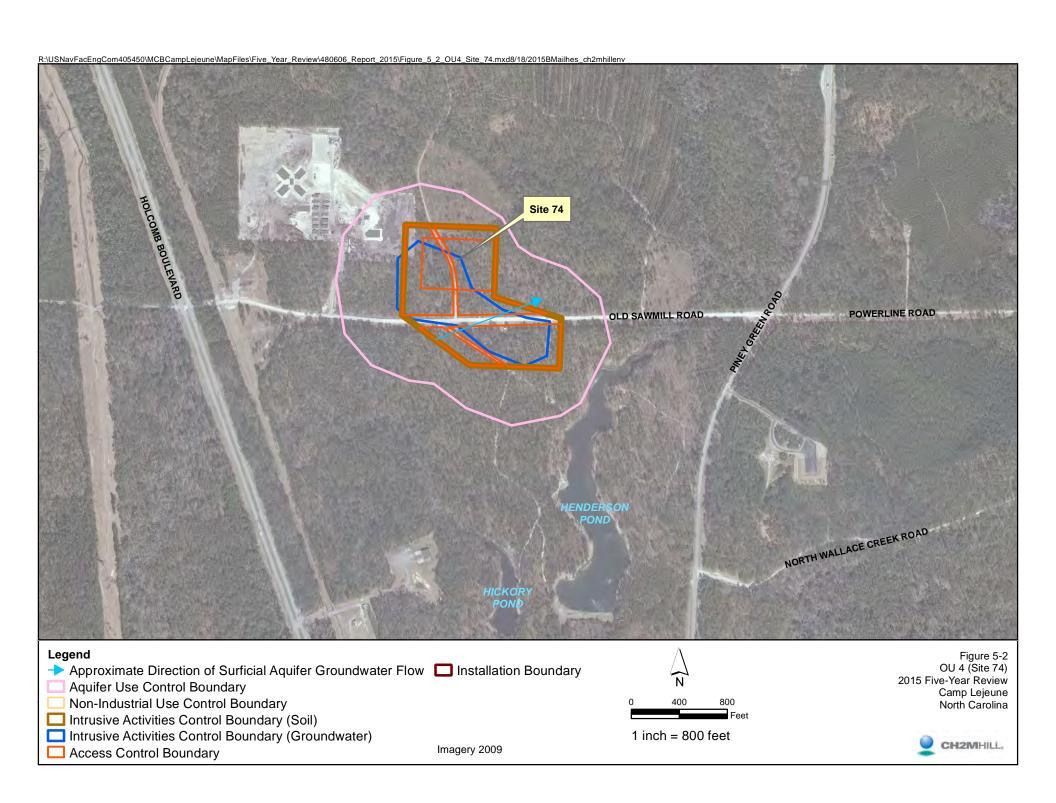
MCL (May 2009)

NCGWQS (April 2013)

TABLE 5-2
OU 4 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome	
	Soil/waste	Potential exposure to chemical agent in waste left in place.		Prevent exposure to contaminated soils and former disposal area materials.	LUCs	Maintain non-industrial land use and intrusive activities control and conduct quarterly monitoring.		
41	Surface Water/Seeps	Potential for groundwater contaminants to discharge to surface water through seeps.	Vacant/Industrial	Vacant/Industrial	Prevent future potential exposure to contaminated groundwater.	LTM	LTM completed. Groundwater cleanup levels were achieved and data indicated no offsite migration.	
		Potential unacceptable	ks to future residents from exposure to etals through potable		LTM	LTM completed. Groundwater cleanup levels were achieved.		
	Groundwater	risks to future residents		Prevent future potential exposure to contaminated groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring. LUCs are in effect because waste remains in place.	Restricted Land Use	
	Soil/waste	Potential exposure to chemical agent in waste left in place.		Prevent exposure to contaminated soils and former disposal area materials.	LUCs	Maintain non-industrial land use and intrusive activities control and conduct quarterly monitoring.		
74		Potential unacceptable	tential unacceptable Vacant/Industrial		LTM	LTM completed. Groundwater cleanup levels were achieved.		
	Groundwater m	risks to future residents from exposure to metals through potable use of groundwater.	from exposure to metals through potable	Prevent future potential exposure to contaminated groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring. LUCs are in effect because waste remains in place.		





Operable Unit 5 (Site 2)

6.1 Site History and Background

OU 5 is within the Mainside of the Base (Figure 1-2) and consists of Site 2.

Site 2 — the Former Nursery/Day Care Center is approximately 5 acres just inside the Main Gate in the northeast portion of the Base (Figure 6-1). From 1945 to 1958, an onsite building (Building 712) was used for the storing, handling, and dispensing of pesticides and was later used as a day care center. Chemicals known to have been used at Site 2 include chlordane, DDT, diazinon, and 4,4'-DDD, dieldrin, lindane, malathion, and silvex. A preliminary soil sampling investigation, conducted in 1982, indicated the presence of pesticides, resulting in the transfer of the day care center to another location.

6.2 Site Characterization

The findings from various investigations at OU 5 that are pertinent to the FYR are summarized in this section.

1983	•IAS
1984- 1990	Confirmation Study
1991- 1992	•Geophysical Investigation
1993- 1994	•RI/FS
1994- 1995	•TCRA to remove pesticide-contaminated soil and sediment
1994	•PRAP/ROD
1995- 2008	•LTM
1997	Notice of Non-Significant Change
2001	•LUCs
2008	•Closeout Report
2011	•Closeout Report Update

6.2.1 Physical Characteristics

- Surface Features OU 5 is primarily flat, but dips sharply at the drainage ditches which run parallel to the Camp Lejeune Railroad. Overland drainage generally drains north towards Overs Creek, located approximately 1,000 feet north of Building 712, and is limited over most of the site due to the flat topography.
- **Geology and Hydrogeology** OU 5 is underlain by unconsolidated deposits of sand, silt, and clay. The surficial aquifer is encountered from approximately 2 to 25 feet bgs in this area. Surficial aquifer groundwater flows north-northwest towards Overs Creek (Baker, 1994a).

6.2.2 Land Use

- Current Land Use Building 712 is currently used as administrative offices.
- Future Land Use There are no anticipated changes in land use.

6.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 5 RI report (Baker, 1994a) and the OU 5 ROD (Baker, 1994b).

- Pesticides were detected in soil and sediment near the former mixing pads, and VOCs, primarily petroleumrelated compounds, were identified in surficial aquifer groundwater. Metals were detected in soil, sediment, and groundwater.
- An HHRA and ERA were completed for Site 2 as part of the RI. Potential human health risks were identified for
 future residents and current Base personnel due to exposure to pesticides in soil and sediment, and pesticides,
 VOCs, and metals in groundwater (residents only). Potential ecological risks were identified for aquatic and
 terrestrial receptors due to the presence of pesticides in sediment and soil (Baker, 1994a).

ES120414012346RAL 6-1

6.2.4 Interim Removal Actions

After the completion of the HHRAs and ERAs but before the completion of the ROD, a TCRA was implemented to remove pesticide-contaminated soils above the industrial RSL (OHM, 1995). A total of 1,048 tons of soil were excavated from three areas and disposed of as hazardous waste. As a result, the unacceptable risks from exposure to soil and sediment for current Base personnel and ecological receptors were removed.

6.3 Remedial Action Objectives

The ROD addressing groundwater at OU 5 was signed on September 15, 1994 (Baker, 1994b). The RAOs identified for OU 5 are:

- Prevent future human exposure to the contaminated groundwater.
- Ensure, through monitoring, that there are no human or environmental exposures due to migration of the contaminant plume off site.

The cleanup levels for OU 5 are presented in **Tables 6-1** and **6-2**.

6.4 Remedial Actions

The OU 5 RA components and expected outcomes are summarized in **Table 6-3**. The RA for OU 5 includes the following major components:

- LTM of groundwater to assess changes in COC concentrations and extent.
- LUC implementation for soil and groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the surficial aquifer within 1,000 feet of the estimated impacted groundwater extent.
 - Prohibit the installation of new groundwater supply wells within the vicinity of OU 5.
 - Restrict intrusive activities within the vicinity of the estimated impacted groundwater extent.
 - Prohibit non-industrial land use within the extent of the former soil removal which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.

6.4.1 Remedy Implementation

LTM at Site 2 was initiated in 1995. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002). The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

6.4.2 Remedy Operation and Maintenance

Long-term Monitoring

The LTM Program at Site 2 included annual sampling of six surficial aquifer monitoring wells for analysis of VOCs. In 2007, groundwater VOC concentrations were below cleanup levels for four consecutive events. As a result, LTM was discontinued and a Final Site Closeout Report was submitted in September 2008 (CH2M HILL, 2008).

Land Use Controls

Because LTM was completed and the cleanup levels in groundwater have been achieved, LUCs restricting groundwater intrusive activities and aquifer use were removed. LUCs remain in place to prohibit non-industrial use within the extent of the former soil removal actions. The LUCs are shown on **Figure 6-1** and summarized in **Table 6-4**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

6-2 ES120414012346RAL

TABLE 6-4
OU 5 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Updates
Non-Industrial Use Control Boundary (Soil)	3.3	September 2008	June 2009

6.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 6-5.

TABLE 6-5 2010 FYR OU 5 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Closeout Report does not identify that metals were removed as COCs	Issue a correction to the Closeout Report to include and explain the Notice of Non-Significant Change (USMC, 1997) and document recent data and findings. (2012)	Completed in December 2011. A Technical Memorandum provided an update to the Closeout Report to incorporate the Notice of Non-Significant Changes (CH2M HILL, 2011). The memorandum addressed the recommendations from the FYR to include and explain rationale for removing metals as COCs to the groundwater monitoring program from the ROD (Baker, 1994b).

6.5 Technical Assessment

Is the remedy functioning as designed?

Yes. LUCs remain in place to prohibit non-industrial use within the extent of the former soil removal actions. However, based on review of the soil and sediment data from the TCRA Closeout Report (OHM, 1995) in comparison to the current (May 2014) USEPA RSLs, the pesticide concentrations in the confirmation samples are below the most conservative value (**Table 6-2**). Therefore, it is recommended that the LUCs to prohibit non-industrial use be removed.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The cleanup levels for groundwater were identified as the more conservative of the Federal MCLs or NCGWQSs at the time the ROD was signed. However, cleanup levels were not identified for SVOCs or pesticides in the ROD because risk-based remediation goals calculated during the FS were not exceeded and these contaminants were not included in the LTM remedy (Baker, 1994c). NCGWQS and MCLs available for these 8 COCs are included in **Table 6-1**. Cleanup levels for VOCs have been achieved and LTM was discontinued (CH2M HILL, 2008). LTM for metals was discontinued based on the Notice of Non-Significant Change (CH2M HILL, 2011). As noted in the 2010 FYR, there is no history or evidence of metals disposal at the Site and the metals concentrations were determined not to be site-related.

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 5.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes in toxicity values, regulatory levels, and risk characteristics of some contaminants detected in groundwater (**Table 2-1**), these changes would not affect the protectiveness of the selected remedy as it would not substantially change the results of the risk assessment or the cleanup goals because groundwater LTM is complete (CH2M HILL, 2008).

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

ES120414012346RAL 6-3

6.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 5 are summarized in Table 6-6.

TABLE 6-6
OU 5 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight	Milestone Date		otectiveness (/N)
		responsible	Agency	Date	Current	Future
Confirmation soil and sediment data does not exceed residential RSLs	Remove non-industrial use LUC and prepare a RACR	Navy/Base	USEPA/State	6/30/2016	N	N

6.7 Statement of Protectiveness

The remedy at OU 5 is protective because cleanup levels for UU/UE have been achieved. Groundwater LTM is complete because cleanup levels for COCs have been met, furthermore soil concentrations in confirmation samples after the TCRA are below residential RSLs.

6.8 References

Baker. 1994a. *Remedial Investigation Report, Operable Unit No. 5, Site 2*. Marine Corp Base, Camp Lejeune, North Carolina. June.

Baker. 1994b. Record of Decision, Operable Unit Number 5 – Site 2. Marine Corp Base Camp Lejeune. September.

Baker. 1994c. Feasibility Study, Operable Unit No. 5, Site 2. Marine Corp Base, Camp Lejeune, North Carolina.

Baker. 2002. Land Use Control Implementation Plans. Marine Corps Base Camp Lejeune, North Carolina. July 2002.

CH2M HILL. 2008. Closeout Report, Operable Unit No. 5 – Site 2, Marine Corps Base Camp Lejeune. September.

CH2M HILL. 2010. Five-Year Review, Marine Corps Base Camp Lejeune. August.

CH2M HILL. 2011. Technical Memorandum Update to the Operable Unit No. 5 - Site 2 Closeout Report. December.

OHM, 1995. Contractor's Closeout Report Time Critical Removal Action for Pesticide Contaminated Soil Operable Unit 5, Site 2, Marine Corps Base, Marine Corps Base Camp Lejeune, North Carolina.

USMC, 1997. Notice of Non-Significant Changes: OU 1 (Sites 24 and 78) and OU 5 (Site 2), Marine Corps Base Camp Lejeune. July.

6-4 ES120414012346RAL

TABLE 6-1
Groundwater Cleanup Levels for OU 5 (Site 2)
2015 Five-Year Review

Media	COCs	ROD Cleanup Levels	Current Cleanup Level			
iviedia	Cocs	(Baker, 1994)	Concentration	Reference		
	VOCs					
	Ethylbenzene	29	600	NCGWQS		
	Trichloroethene	2.8	3	NCGWQS		
	Xylene (total)	530	500	NCGWQS		
	SVOCs					
	Acenaphthene	NS	80	NCGWQS		
	2,4-Dimethyphenol	NS	100	NCGWQS		
	2-Methylnaphthalene	NS	30	NCGWQS		
	Naphthalene	NS	6	NCGWQS		
Groundwater (μg/L)	Phenol	NS	30	NCGWQS		
	Pesticides					
	4,4'-DDD	NS	0.1	NCGWQS		
	4,4'-DDT	NS	0.1	NCGWQS		
	Metals	-	•	•		
	Arsenic	50	10	NCGWQS/MCL		
	Barium	2,000	700	NCGWQS		
	Beryllium	4	4	MCL		
	Lead	15	15	NCGWQS/MCL		
	Vanadium	NS	8.6	RSL-Tapwater		

Notes:

Shading indicates cleanup levels achieved per Closeout Report (CH2M HILL, 2008)

NS - Not specified

Cleanup Level Reference Dates:

MCL (May 2009)

NCGWQS (April 2013)

RSL (November 2014)

TABLE 6-2
Soil Cleanup Levels for OU 5 (Site 2)
2015 Five-Year Review
Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels (Baker, 1994)	2014 Adjusted ¹ Industrial Soil RSL ²	2014 Adjusted ¹ Residential Soil RSL ²	Maximum Concentration ³
	Pesticides				
	4,4-DDT	3,000	8,600	1,900	1,400
	4,4-DDE	3,000	6,800	1,600	630
Soil (μg/kg)	4,4-DDD	4,000	9,600	2,200	81.9
3011 (μg/ κg/	Dieldrin	50	140	33	31
	Heptachlor	179	510	120	0.6
	Chlordane (total)	621	8,000	1,800	78
	Pesticides				
	4,4-DDT	15,000	86,000	19,000	5,500
	4,4-DDE	15,000	68,000	16,000	300
Sediment (μg/kg)	4,4-DDD	21,000	96,000	22,000	2,800
Seument (μg/kg)	Dieldrin	NS	1,400	330	Not detected
	Heptachlor	NS	5,100	1,200	Not detected
	Chlordane (total)	4,000	80,000	18,000	Not detected

Notes:

Shading indicates cleanup levels achieved

NS: Not specified

¹RSLs are adjusted for non-carcinogens by dividing the RSL by 10 to account for cumulative effects from exposure to multiple chemicals

²Industrial and Residential RSL was multiplied by 10 for sediment

³Contractors Closeout Report, TCRA for Pesticide Contaminated Soil (OHM, 1995)

TABLE 6-3
OU 5 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
	Groundwater	Potential unacceptable risks to future residents from exposure to pesticides, VOCs, and metals in groundwater.		Ensure, through monitoring, that there are no human or environmental exposures due to migration of the contaminant plume off site.	LTM	LTM complete after four consecutive rounds below groundwater cleanup levels.	
G				Prevent future human exposure to contaminated groundwater.	LUCs	Groundwater cleanup levels were met and aquifer use and intrusive restrictions for groundwater have been removed.	
2		Potential unacceptable risks to future resident, current Base personnel, and ecological	Industrial	Remove soil with concentrations of pesticides that present a potential risk to human health and the environment	Soil Removal	TCRA to remove soil above industrial levels is complete. Removal was planned to industrial RSL; residential RSLs have also been met.	UU/UE
		receptors from pesticides in soil.		(TCRA).	LUCs	Residential RSLs have been met and non-industrial use controls can be removed.	
		Potential unacceptable risks to future resident, current Base personnel, and ecological receptors from pesticides in		Remove sediment with concentrations of pesticides that present a potential risk to human	Sediment Removal	TCRA to remove sediment to industrial levels is complete. Removal was planned to industrial RSL; residential RSLs have also been met.	
		sediment.		health and the environment (TCRA).	LUCs	Residential RSLs have been met and non-industrial use controls can be removed.	



Operable Unit 6 (Sites 36, 43, 44, and 54)

7.1 Site History and Background

OU 6 is within the Camp Geiger and MCAS New River portions of the Base (**Figure 1-2**). OU 6 consists of four sites (Sites 36, 43, 44, and 54) that have been grouped together because of the similar characteristics of material disposed and geographic location.

Site 36 — Camp Geiger Area Dump is

approximately 64 acres in the northwest portion of the Base (Figure 7-1). Site 36 is reported to have been used for the disposal of municipal wastes and mixed industrial wastes including trash, waste oils, solvents, and hydraulic fluids that were generated at MCAS New River. The dump was active from the late 1940s to the late 1950s. Most of the material was burned and buried.

Site 43 — Agan Street Dump is approximately 14 acres and reportedly received inert material such as construction debris and trash (Figure 7-1). Sludge from the former sewer treatment plant was also reportedly dumped onto the ground surface; however, it is not clear when disposal operations took place.

Site 44 — **Jones Street Dump** is approximately 6 acres and was reportedly in operation during the 1950s (**Figure 7-1**). Although the quantity of waste is not known, debris, cloth, lumber, and paint cans were reportedly disposed of at the site.

Site 54 — Crash Crew Fire Training Burn Pit is approximately 1 acre and has served as the fire training burn pit since the mid-1950s (Figure 7-1).

1983	•IAS (Site 36, 43, 44, & 54)	
1984- 1987	•Confirmation Study (Site 36 & 54)	
1991	•Site Investigation (Site 43 & 44)	
1994- 1996	•RI (Site 36)	
1995- 2002	•RI/FS (Site 43, 44, & 54)	
1995	•Interim RA (Site 43)	
1997	•TCRA (Site 36)	
1998- resent	•LTM (Site 36)	
1998- resent	•RIP and Interim RACR (Site 36)	
1998- 2002	•LTM (Site 54)	
1998- 2002	•FS (Site 36)	
2001	•Interim RA (Site 54)	
2003	•Interim RA (Site 36)	
2005	•ROD (Site 36, 43, 44, & 54)	
2005- 2007	•RIP and Interim RACR (Site 43, 44, & 54)	

The former Crash Crew Fire Training Burn Pit was 90 feet in diameter and situated at the center of this site. Originally, fire training was conducted on the ground surface within a bermed area using JP-type fuel, which was stored in an 8,000-gallon UST northwest of the burn pit. An OWS, located approximately 100 feet southeast of the burn pit, was used for temporary storage and collection of the spent fuel. In 1975, a lined burn pit was constructed and was used until 1999. Beginning in August 2000, the burn pit was converted to a fire training area that employs clean-burning fuels with operational and engineering controls. It is estimated that nearly 500,000 gallons of petroleum, oil, and lubricants (POL) may have been used at Site 54.

7.2 Site Characterization

The findings from various investigations at OU 6 that are pertinent to the FYR are summarized in this section.

7.2.1 Physical Characteristics

Surface Features – Sites 36, 43, and 44 are primarily wooded. Site 36 is bisected by an access road to a
recreational area on the New River and Brinson Creek is located along the northeast boundary. Storm water
from Site 36 flows toward Brinson Creek. Edwards Creek is located along the northern boundary of Site 44 and

ES120414012346RAL 7-1

the ground slopes steeply toward the creek. Storm water flows toward Edwards Creek at Site 43 and 44. Site 54 is primarily paved and flat.

• Geology and Hydrogeology – Subsurface conditions at the OU 6 sites generally consist of Coastal Plain deposits comprising layers of sand, silt, and clay. The surficial aquifer extends from 2 to 40 feet bgs, where the UCH aquifer is encountered. Groundwater in the surficial aquifer typically flows to the east and northeast across Site 36 where it is expected to discharge to Brinson Creek. Groundwater in the surficial aquifer at Sites 43 and 44 is expected to flow to the north and discharge to Edwards Creek. Groundwater in the surficial aquifer at Site 54 is expected to flow south and discharge to a tributary of South West Creek (Figure 7-1). Groundwater in the Castle Hayne aquifer typically flows toward the northeast and the New River. Groundwater is not a medium of concern at Sites 43, 44, and 54 (Baker, 1996).

7.2.2 Land Use

- Current Land Use There are no ongoing operations at any of the OU 6 sites. The access road at Site 36 is
 used by military personnel for recreation and to access a picnic area located adjacent to the New River.
 Fishing may occur in Brinson Creek and the New River. Site 54 is located within MCAS New River and is
 accessed by military personnel who work at the air station, and runway construction is currently underway
 within the site boundary.
- **Future Land Use** There are no anticipated changes in land use.

7.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 6 RI report (Baker, 1996) and the OU 6 ROD (CH2M HILL and Baker, 2005).

Site 36

- Pesticides, PAHs, PCBs, and metals in soil and VOCs in groundwater were detected during the RI.
- An HHRA and ERA were completed for Site 36 as part of the RI. Potential unacceptable human health risks were identified for current recreational fishermen from ingestion of fish containing arsenic and mercury (Baker, 2005). Potential unacceptable human health risks were identified for child trespassers and future child residents from lead in surface soil and crab tissue. Potential unacceptable human health risks were also identified for future child residents based on exposure to iron in groundwater and subsurface soil and future adult residents based on exposure to iron in groundwater. Although risks were not identified from exposure to VOCs in groundwater, the concentrations exceeded the NCGWQS and MCL, and the RI recommended including Site 36 in the LTM program to monitor VOCs in groundwater and surface water. Based on historical dumping activities conducted at the site, potential human health risks from exposure to contaminants in buried waste and affected soil are assumed. No unacceptable ecological risks were identified; however, because groundwater is a potential source of VOCs to surface water, there is a potential for future unacceptable risk to aquatic receptors (Baker, 1996).

Site 43

- PAHs, pesticides, and metals were detected in soil, and pesticides and metals were detected in surface water and sediment. Metallic debris was observed on the ground surface.
- An HHRA and ERA were completed for Site 43 as part of the RI. Potential unacceptable risks were identified for future residents from exposure to iron and aluminum in groundwater. However, based on the geochemical conditions (neutral pH) and background concentrations, the metals were considered to be naturally occurring and not likely a result of leaching from buried debris. Based on historical dumping activities conducted at the site, potential human health risks from exposure to contaminants in buried waste and affected soil are assumed. There were no unacceptable ecological risks at Site 43 (Baker, 1996).

7-2 ES120414012346RAL

Site 44

- VOCs and metals were detected in groundwater. VOCs, SVOCs, and metals were detected in surface water and SVOCs and pesticides and metals were detected in sediment.
- An HHRA and ERA were completed for Site 44 as part of the RI. Potential unacceptable risks were identified
 for future residents from exposure to VC and iron in groundwater. The VC was considered to be related to an
 upgradient source (Site 89) and iron is naturally occurring and not related to site activities. Based on historical
 dumping activities conducted at the site, potential human health risks from exposure to contaminants in
 buried waste and affected soil are presumed. There were no unacceptable ecological risks at Site 44
 (Baker, 1996).

Site 54

- VOCs, SVOCs, and metals were detected above screening levels in groundwater.
- An HHRA and ERA were completed for Site 54 as part of the 1996 RI. Potential unacceptable risks were identified for future residents based on exposure to VOCs, SVOCs, and lead in groundwater. However, post-RI groundwater monitoring indicated that the VOCs, SVOCs, and metals were below NCGWQS and monitoring was discontinued in 2002, before the ROD was signed. Based on the ERA, potential impacts to soil invertebrates and plants were identified from SVOCs and metals; however, there were no unacceptable ecological risks to terrestrial vertebrates and the site is not considered an ecological habitat (Baker, 1996).

7.2.4 Interim Removal Actions

After completion of the HHRAs and ERAs but before completion of the ROD, interim removal actions were completed at Sites 36, 43, and 54.

Site 36

Although risks were not identified from exposure to PAHs, pesticides, and PCBs in soil, isolated areas with exceedances of screening levels were targeted for removal. In 1997, approximately 92 tons of regulated PCB-contaminated soil and 148 tons of non-regulated PCB-contaminated soil was removed from Site 36 during a TCRA. Confirmation samples exhibited PCB concentrations below the industrial action level (10 milligram per kilogram [mg/kg], Baker, 2002).

In 2003, a TCRA was implemented to remove "hot spot" areas that exceeded residential levels for PAHs and pesticides. A total of 1,630 tons of PAH- and pesticide-contaminated soil was removed from four areas within the south central portion of the site (Shaw, 2003). Based on historical use as a disposal area buried waste and lead contaminated soil may remain at Site 36.

Site 43

During the RI field investigations, several debris items that could potentially present a hazard to human health or the environment were observed on the ground surface. In 1995, 14,660 pounds of metallic debris were removed from the surface and recycled, and four drums containing paint cans were disposed of offsite as hazardous waste (OHM, 1995).

In 2003, a TCRA was implemented to remove "hot spot" areas that exceeded residential levels for PAHs. A total of 1,478 tons of PAH-contaminated soil was excavated and disposed offsite (Shaw, 2003). Based on historical use as a disposal area buried waste may remain at Site 43.

Site 54

In 2001, the UST and associated POL-contaminated soil and construction debris were removed from the former burn pit area to industrial levels. The excavation was 9 feet deep and was roughly oval in shape with a length of 128 feet and a width of 96.5 feet (OHM, 2001). A new concrete-lined fire training area and two propane tanks were constructed onsite. Soil impacts above the residential cleanup levels remain in place in the former burn pit area.

ES120414012346RAL 7-3

7.3 Remedial Action Objectives

The ROD addressing soil and groundwater at OU 6 was signed in July 2005 (CH2M HILL/Baker, 2005). The RAOs identified for OU 6 are:

Site 36

- Protect human health by preventing exposure to surface and subsurface soil within the following areas: lead
 contaminated areas, and unknown disposal materials within the former dump, and the previous soil removal
 action areas (i.e., PCB, PAH, and pesticide removal action areas).
- Prevent future exposure to VOC-contaminated groundwater and assess natural attenuation of groundwater contamination.
- Protect uncontaminated groundwater for future potential beneficial use.

Site 43

• Prevent future exposure to the surface and subsurface soil within the former site-wide dump from unknown disposed materials and the previous soil removal action area (i.e., PAH removal action area).

Site 44

 Prevent future exposure to the surface and subsurface soil due to unknown disposed materials within the former site-wide dump.

Site 54

Prevent future exposure to the surface and subsurface soil within the former burn pit area.

The cleanup levels for OU 6 are presented in Table 7-1.

7.4 Remedial Actions

The OU 6 RA components and expected outcomes are summarized in **Table 7-2**. The RA for OU 6 includes the following major components:

Site 36

- LTM of groundwater to assess effectiveness of Monitored Natural Attenuation (MNA)
- LTM of surface water to assess potential discharge to Brinson Creek
- Annual groundwater modeling to evaluate natural attenuation

Sites 36, 43, 44, and 54

- LUC implementation for soil and groundwater as follows:
 - Prohibit non-industrial land use, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities
 - Restrict intrusive activities within the site boundaries
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring, from the aquifers (surficial and Castle Hayne) within 1,000 feet of the estimated impacted groundwater extent (Site 36 only)

7.4.1 Remedy Implementation

LTM was initiated at Site 36 in 1998. LUCs for OU 6 were implemented in 2005. The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

7-4 ES120414012346RAL

7.4.2 Remedy Operation and Maintenance

Long-term Monitoring

LTM at Site 36 currently includes collecting samples from three surficial, six UCH, and one MCH aquifer monitoring wells, and four surface water locations. Sampling locations are shown on **Figure 7-1**. Groundwater and surface water samples are analyzed for VOCs biennially, and groundwater samples are analyzed for natural attenuation indicator parameters (NAIPs – methane, ethane, ethene [MEE], alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon) every five years to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs.

Natural attenuation in groundwater is modeled using BIOCHLOR (Aziz and Newall, 2002). Biennial BIOCHLOR modeling predicts attenuation of 1,1,2,2-PCA in 56 years, TCE in 44 years, and VC in 71 years. In order to reduce this timeframe for site closure, a pilot study is planned in 2015 to evaluate the use of alternative remediation options for groundwater at Site 36. In 2013, 1,2-DCA was removed as a COC because concentrations did not exceed the cleanup level within 4 consecutive rounds of sampling (CH2M HILL, 2014).

The annual cost of LTM at OU 6 is approximately \$20,000.

Land Use Controls

Access control signs are present at Sites 43 and 44, and Site 44 is currently surrounded by a chain-link fence to restrict access. The LUCs are shown on **Figure 7-1** and summarized in **Table 7-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed. During the MCAS New River runway expansion project, soil grading activities took place within the Site 54 intrusive activities boundary with prior USEPA and NCDENR written notification. Once the runway expansion project is complete, concrete will cover all or part of the intrusive control boundary.

TABLE 7-3
OU 6 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
	Site 36		
Non-Industrial Use Control Boundary (Soil)	4.8		
Intrusive Activities Control Boundary (Soil)	4.8	Cautaudau 2005	F-h 2007
Intrusive Activities Control Boundary (Groundwater)	4.8	September 2005	February 2007
Aquifer Use Control Boundary (1,000 feet)	64.8		
	Site 43		
Non-Industrial Use Control Boundary (Soil)	0.14	Cantanahan 2005	February 2007
Intrusive Activities Control Boundary (Soil)	13.2	September 2005	
	Site 44		
Intrusive Activities Control Boundary (Soil)	5.6	Cantanahan 2005	F-h 2007
Non-Industrial Use Control Boundary (Soil)	5.6	September 2005	February 2007
	Site 54		
Non-Industrial Use Control Boundary (Soil)	0.29	September 2005 February 2	
Intrusive Activities Control Boundary (Soil)	0.29		

ES120414012346RAL 7-5

7.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in **Table 7-4**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources at Site 36 is shown on **Figure 7-2**.

TABLE 7-4
2010 FYR OU 6 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Cleanup levels have changed since the ROD	Update Site 36 groundwater COCs and cleanup levels to reflect current standards. (2012)	Completed in 2011. Cleanup levels have been updated to reflect current NCGWQS.
VI potential at Site 36	Evaluate and mitigate VI pathway during construction planning. (ongoing)	There is no unacceptable risk from VI based on current land use. If buildings are planned for construction in the vicinity of the VOC groundwater plume, the potential for a VI pathway is evaluated and mitigated if needed. Base Master Planning maintains current groundwater plume data in the GIS, and all construction projects on-Base go through environmental review.
Monitoring wells remain in place at Sites 43, 44, and 54	Abandon existing monitoring wells in accordance with NC Regulations. (2012)	Completed in 2012. Monitoring wells were abandoned at Site 43 and 44. A visual inspection of the site confirmed that no monitoring wells were present at Site 54.

7.5 Technical Assessment

Is the remedy functioning as designed?

Site 36

No. Based on the review of LTM results, MNA conditions appear to be marginal and VOC trends in groundwater from monitoring wells within the UCH aquifer show that concentrations of TCE are stable or slightly decreasing and degradation products cis-1,2-DCE and VC are also stable or decreasing (**Figure 7-3**).

The first post-ROD round of LTM data and most recent LTM data are shown on **Table 7-5**. The extent of TCE and VC over time in the surficial aquifer are shown on **Figures 7-4** and **7-5**, and in the UCH on **Figures 7-6** and **7-7**. Although concentrations at individual locations appear to have decreased, the overall plume shape and concentrations are within the same order of magnitude as initial data and are consistently 10 to 100 times the respective NCGWQS for TCE and VC. An increase in daughter products would be expected as TCE decreases; however, this does not appear to be occurring.

TABLE 7-5 Select COC Concentrations in the UCH Aquifer - Site 36

coc	IR36-GW10IW		IR36-GW16IW		IR36-GW21IW	
(μg/L)	Post-ROD LTM (Sept 2006)	LTM (Dec 2013)	Post-ROD LTM (Sept 2006)	LTM (Dec 2013)	Post-ROD LTM (Sept 2006)	LTM (Dec 2013)
TCE	46	29.3	35	17.3	50	38.2
cis-1,2-DCE	21	11.1	10	7.11	3.8	1.53
VC	1.5	1.1	1	0.59	0.42 J	0.5 U

J – Analyte present, value may or may not be accurate or precise

NAIP data was collected from LTM monitoring wells in December 2013 and conditions appear to be marginal for reductive dechlorination (**Table 7-6**). Some of the more favorable indicators included ORP in the UCH (negative or

7-6 ES120414012346RAL

U – The material was analyzed for, but not detected

less than 50 millivolts [mV]), nitrate (not detected), and ferrous iron in the UCH (measurable levels). Elevated alkalinity provides buffering capacity during degradation. Elevated chloride concentrations measured in some locations in the surficial aquifer is another indicator of reduction dechlorination; however, concentrations were significantly lower in the UCH. DO in the surficial aquifer is higher than 1 in most samples, indicating aerobic conditions, which are not typically favorable for reductive dechlorination; however, VC can degrade aerobically. Total organic carbon (TOC) in both aquifer zones was low, which may be unfavorable for microbial growth. A pilot study is being conducted to enhance reductive dechlorination of COCs. Performance monitoring of the pilot study will be conducted on a quarterly basis for 9 months post implementation.

While the BIOCHLOR model predicts that TCE is reaching Brinson Creek at a concentration exceeding the surface water standard, TCE was not detected at concentrations above laboratory reporting limits in samples collected from Brinson Creek in December 2013 and the groundwater concentration in the nearest surficial aquifer monitoring well is less than the NCSWQS. The model is based on data from the surficial and UCH aquifers; however, based on the depth of the UCH aquifer samples (35 to 40 feet bgs), the relatively low upward vertical gradient of 0.03 feet per foot at the IR36-GW10 cluster (Baker, 1996), and the fact that COCs have not been detected in surface water, it is not likely that the UCH aquifer is discharging into Brinson Creek. Based on these lines of evidence and the planned pilot study, natural attenuation modeling may not be an appropriate remedy component and an alternative approach to natural attenuation evaluation and protection of Brinson Creek is recommended. Since surface water does not exceed the cleanup level and surficial groundwater immediately upgradient from Brinson Creek does not exceed the NCSWQS, sampling surface water should be discontinued unless surficial groundwater upgradient to the creek exceeds 10 times the NCSWQS.

LUCs remain in place to prevent exposure to groundwater COCs and soil COCs at concentrations above cleanup levels.

Sites 43, 44, and 54

Yes, the remedy is functioning as designed at Sites 43, 44, and 54. LUCs remain in place to restrict non-industrial landuse and intrusive activities in soil. Additionally, fencing and signs were installed to restrict access. No issues concerning the protectiveness of the remedies in place were noted at Sites 43, 44, and 54 during the site inspections.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No, the cleanup levels for groundwater were identified as the more conservative of the Federal MCLs or NCGWQS at the time the ROD was signed. Since that time, the standards have been updated as listed in **Table 7-1**. During the 2010 FYR, several VOCs that were not included in the ROD exceeded cleanup levels. These COCs will remain in the LTM program until they are detected at or below cleanup levels for four consecutive sampling events.

Changes in Exposure Pathways: There are no changes in the site conditions that would affect current exposure pathways or impact the protectiveness of the remedy at OU 6. However, there is a potential for future VI exposure if buildings are constructed within 100 feet of the VOC impacted groundwater at Site 36.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes in toxicity values (**Table 2-1**), there have been no substantive changes in cleanup levels. These changes would not adversely affect the protectiveness of the selected remedy as it would not substantially change the results of the risk assessment.

Has any other information come to light that could question the protectiveness of the remedy?

Yes. The VI pathway has the potential to become complete at Site 36 and an RAO and LUCs should be added to include evaluating the potential for VI pathways if land use changes and mitigation, if needed. Groundwater modeling based on UCH aquifer data may not be appropriate for MNA evaluation and alternative methods of evaluating MNA are recommended. Based on the historical site use at Site 54 as a fire fighting training area, emerging contaminant group PFCs may be present in groundwater. Groundwater sampling to confirm the presence or absence of PFCs is recommended.

ES120414012346RAL 7-7

7.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 6 are summarized in **Table 7-7**.

TABLE 7-7
OU 6 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight	Milestone	Affects Protectiveness (Y/N)	
		Responsible Agency		Date -	Current	Future
Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI) at Site 36		Navy/Base	USEPA/State	6/30/2016	N	Υ
Discontinue BIOCHLOR modeling and surface water sampling as part of LTM; compare groundwater data collected from the most downgradient locations closest to Brinson Creek at Site 36 collected from the most downgradient locations closest to Brinson Creek to 10 times the NCSWQS to monitor future protectiveness of Brinson Creek. If there are exceedances, surface water will be sampled		Navy/Base	USEPA/State	9/30/2016	N	Υ
PFCs are an emerging contaminant group for former firefighting/burn pits and Site 54 is a former firefighting training area Collect groundwater samples for PFCs at Site 54		Navy/Base	USEPA/State	12/30/2017	N	Υ

7.7 Statement of Protectiveness

The remedy at OU 6 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled and LUCs preventing exposure to waste, soil, and groundwater are in place. At Site 36, LTM is ongoing to monitor the VOC plume and migration and LUCs are in place to restrict groundwater intrusive activities and prohibit aquifer use until cleanup levels are achieved. LUCs are in place to prohibit non-industrial use within the extent of the former soil removal action areas at Sites 36, 43, 44, and 54 where possible debris, PAHs, PCBs, and/or lead remain in soil above levels that allow for UU/UE. Because of the former dumping and/or burning activities, LUCs are also in place at Sites 43, 44, and 54 to restrict intrusive activities.

7.8 References

Baker. 1996. Remedial Investigation Operable Unit No. 6 - Sites 36, 43, 44, and 54, Marine Corps Base. Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Norfolk, Virginia. August.

CH2M HILL and Baker. 2005. Record of Decision, Operable Unit No. 6, Sites 36, 43, 44, and 54. Marine Corps Base Camp Lejeune, North Carolina. June.

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OHM. 1995. Contractor's Closeout Report, Time-Critical Removal Action for Surficial Metallic Debris in Operable Unit 6, Site 43. MCB Camp Lejeune, Jacksonville, North Carolina. December.

7-8 ES120414012346RAL

OHM. 2001. *Draft Contractor's Closeout Report for Sites 9 & 54, Marine Corps Base Camp Lejeune*. June.

Shaw Environmental, Inc. (Shaw). 2003. *Interim Removal Action Report Operable Unit No. 6, Sites 36 and 43, Marine Corps Base Camp Lejeune, North Carolina*.

ES120414012346RAL 7-9

TABLE 7-1
Cleanup Levels for OU 6 (Site 36)
2015 Five-Year Review
Camp Lejeune, North Carolina

Media	coc-	ROD Cleanup Levels	Current Cle	eanup Level			
iviedia	COCs	(Baker, 2005)	Concentration	Reference			
	VOCs						
	Benzene		1	NCGWQS			
	1,1-Dichloroethane		6	NCGWQS			
	1,2-Dichloroethane ¹		0.4	NCGWQS			
	1,1-Dichloroethene		7	NCGWQS/MCL			
Groundwater (μg/L)	cis-1,2-Dichloroethene		70	NCGWQS/MCL			
	trans-1,2-Dichloroethene		100	NCGWQS/MCL			
	Trichloroethene	2.8	3	NCGWQS			
	1,1,2,2-Tetrachloroethane	0.17	0.2	NCGWQS			
	Tetrachloroethene		0.7	NCGWQS			
	Vinyl Chloride	0.015	0.03	NCGWQS			
	VOCs						
	Benzene		51	NCSWQS			
	1,1-Dichloroethane		No Standard	Not applicable			
	1,1-Dichloroethene		No Standard	Not applicable			
Surface Water ² (μg/L)	cis-1,2-Dichloroethene		No Standard	Not applicable			
Surface Water (µg/L)	trans-1,2-Dichloroethene		No Standard	Not applicable			
	Trichloroethene		30	NCSWQS			
	1,1,2,2-Tetrachloroethane		4	NCSWQS			
	Tetrachloroethene		3.3	NCSWQS			
	Vinyl Chloride		2.4	NCSWQS			

Notes:

Shading indicates cleanup level achieved per LTM Report (CH2M HILL, 2014)

Cleanup Level Reference Dates:

MCL (May 2009)

NCGWQS (April 2013)

NCSWQS (May 2013)

⁻⁻ COC identified post-ROD based on exceedances of current cleanup levels during LTM

 $^{^{1}}$ COC was removed from LTM after 4 consecutive rounds of sampling with no exceedance of the cleanup level

² Surface water was not identified as a medium of concern in the ROD, however, the LTM program uses the current NCSWQS for comparison purposes.

TABLE 7-2
OU 6 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
		Potential unacceptable risk to future child residents based on iron in groundwater. Potential migration of VOCs in groundwater to indoor air via		Prevent future exposure to VOC-contaminated groundwater and assess natural attenuation of groundwater contamination. Protect uncontaminated groundwater for future	MNA	Groundwater MNA to monitor VOC concentration trends over time until groundwater VOCs are at or below cleanup levels for 4 consecutive monitoring events. If MNA does not appear to be effective, assess alternative treatment technologies to reduce the timeframe to reach site closure.	
	Groundwater	the VI pathway.		beneficial use.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	UU/UE
36		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent future exposure to COCs in indoor air via the VI pathway.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
	Surface Water	Potential migration of VOCs into surface water.	Vacant/Industrial	Prevent future exposure to VOC-contaminated groundwater.	LTM	Surface water LTM to monitor VOC migration to surface water. LTM will continue until groundwater cleanup levels are achieved.	
	Soil and Waste	Potential unacceptable risks to child trespassers and future residents from lead in soil. Potential exposure to contaminants from waste in place.		Protect human health by preventing exposure to surface and subsurface soil within the following areas: lead contaminated areas, unknown disposal materials within the former dump, and the previous soil removal action areas (i.e., PCB, PAH, and pesticide removal action areas).	LUCs		
43	Soil and Waste	Potential exposure to contaminants from waste in place.		Prevent future exposure to the surface and subsurface soil within the former site-wide dump from unknown disposed materials and the previous soil removal action area (i.e., PAH removal action area).	LUCs	Waste debris remains on site and soil removal was completed to industrial levels. Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	Industrial Land Use
44	Soil and Waste	Potential exposure to contaminants from waste in place.		Prevent future exposure to the surface and subsurface soil due to unknown disposed materials within the former site wide dump.	LUCs		
54	Soil	Potential unacceptable risks to future residents from exposure to PAHs in soil.		Prevent future exposure to the surface and subsurface soil within the former burn pit area.	LUCs		

Note:

Shading indicates Risks/Basis of Action resulting from changing site conditions, exposure pathways, or assumptions that were not present at the time of the ROD. The proposed RAO, Remedy Component, and Performance Metric are included.

TABLE 7-6
Site 36 Summary of NAIPs - December 2013
2015 Five-Year Review
Camp Lejeune, North Carolina

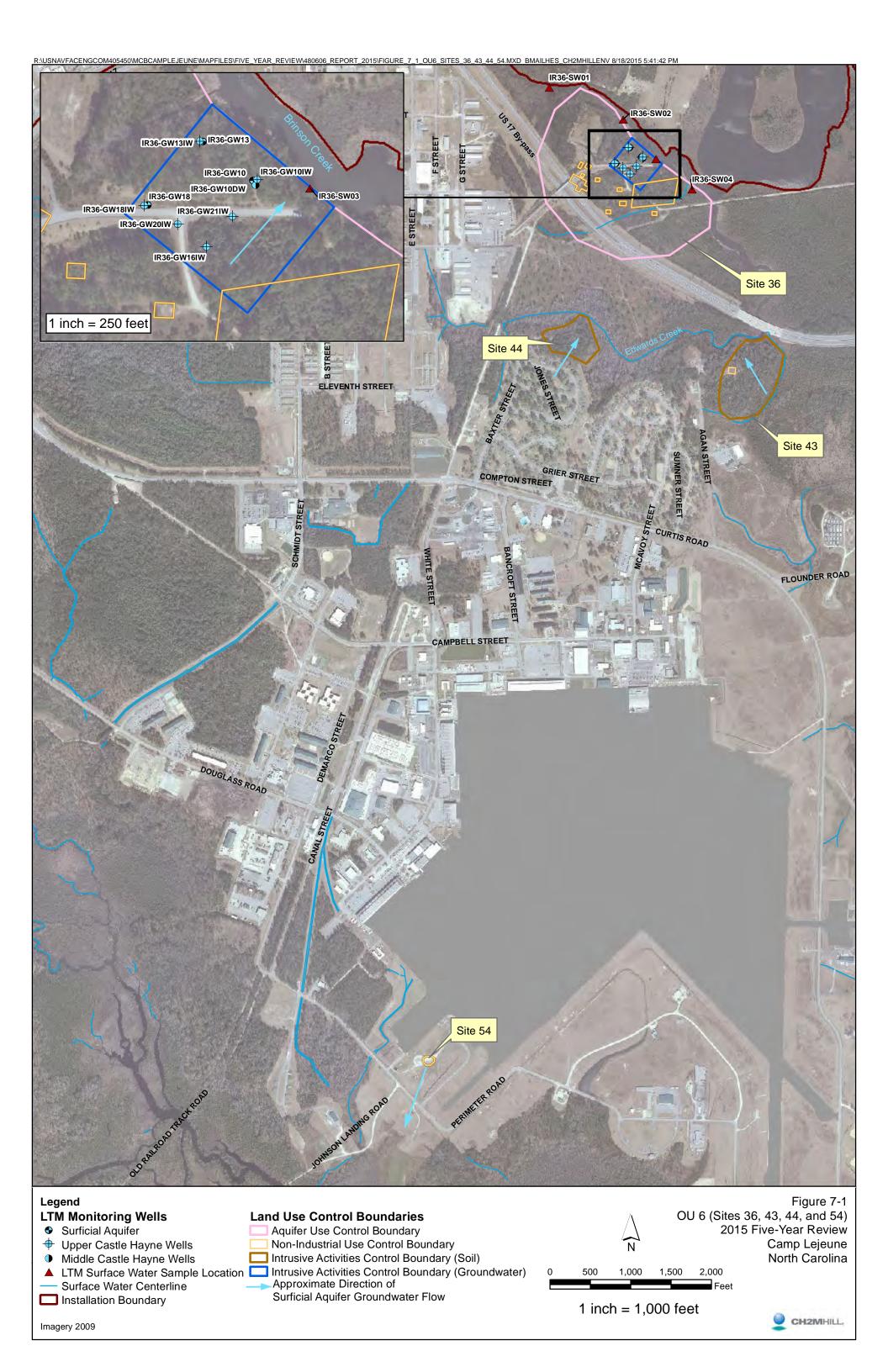
Indicator Parameter	Range of Results	Condition for favorable reductive pathway
Surficial Aquifer		
ORP (mV)	10.6 to 247.1	Less than +50 mV (favorable)
OKF (IIIV)	10.0 (0 247.1	Less than -100 mV (ideal)
DO (mg/L)	0.29 to 7.52	Less than 1.0 mg/L
Nitrate (mg/L)	0	Less than 1.0 mg/L
Ferrous Iron (mg/L)	0 to 4	Measurable Levels
Sulfate (mg/L)	105 to 246	Less than 20 mg/L
Alkalinity (mg/L)	361 to 381, average 372	2x Above ¹ Background (1)
Chloride (mg/L)	14.4 to 18.2, average 16.8	2x Above ¹ Background (7.08)
Methane (μg/L)	2.75 to 33.8	>500 μg/L
Total Organic Carbon (mg/L)	1.72 to 6.34	>20 mg/L
Upper Castle Hayne Aquifer		
ODD (m)/	20 1 270	Less than +50 mV (favorable)
ORP (mV)	-39 to 179	Less than -100 mV (ideal)
DO (mg/L)	0 to 0.85	Less than 1.0 mg/L
Nitrate (mg/L)	0	Less than 1.0 mg/L
Ferrous Iron (mg/L)	0 to 3.8	Measurable Levels
Sulfate (mg/L)	63 to 112	Less than 20 mg/L
Alkalinity (mg/L)	283 to 368, average 339	Above ¹ Background (288)
Chloride (mg/L)	19 to 51, average 31	Above ¹ Background (16)
Methane (μg/L)	1.3 to 460	>500 μg/L
Total Organic Carbon (mg/L)	1.58 to 3.16	>20 mg/L

Notes:

¹Background data from monitoring wells outside of historical plume area:

Surficial - IR89-MW35

Upper Castle Hayne Aquifer - IR89-MW35IW



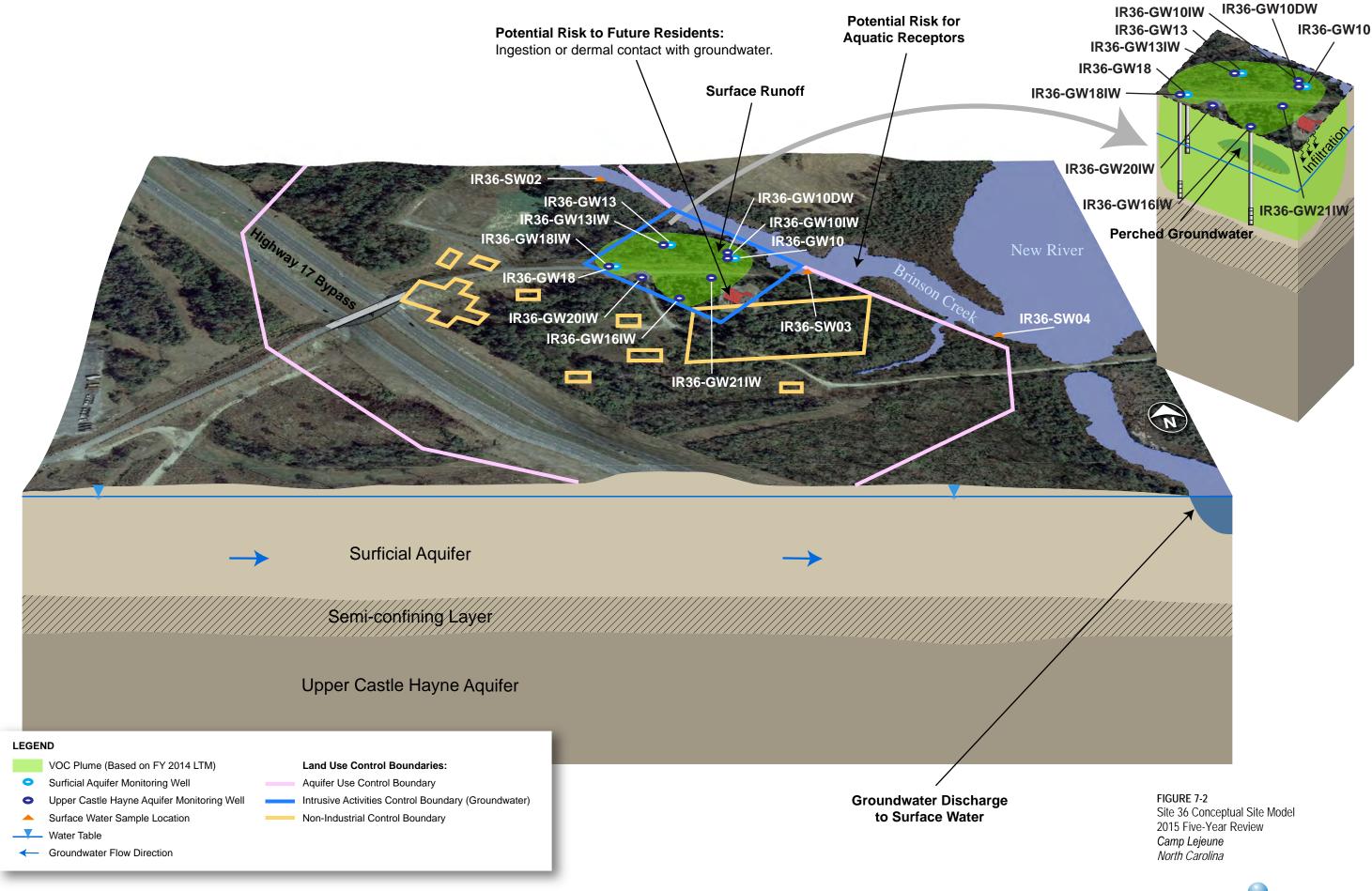
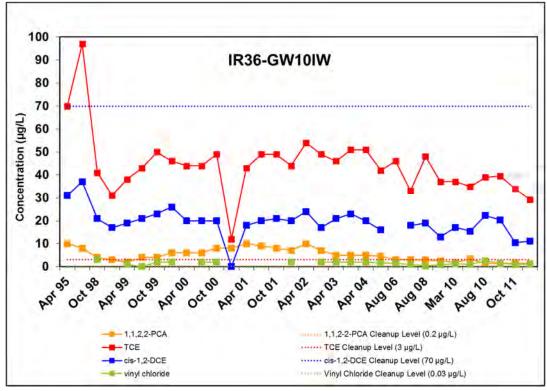
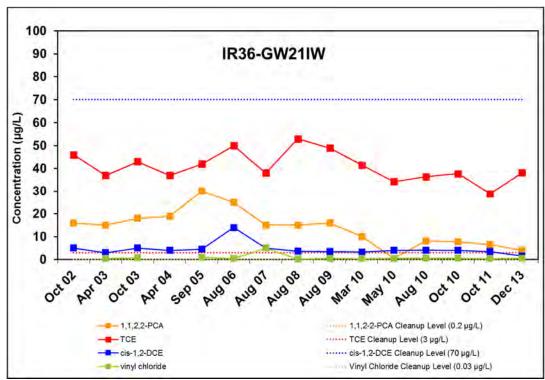
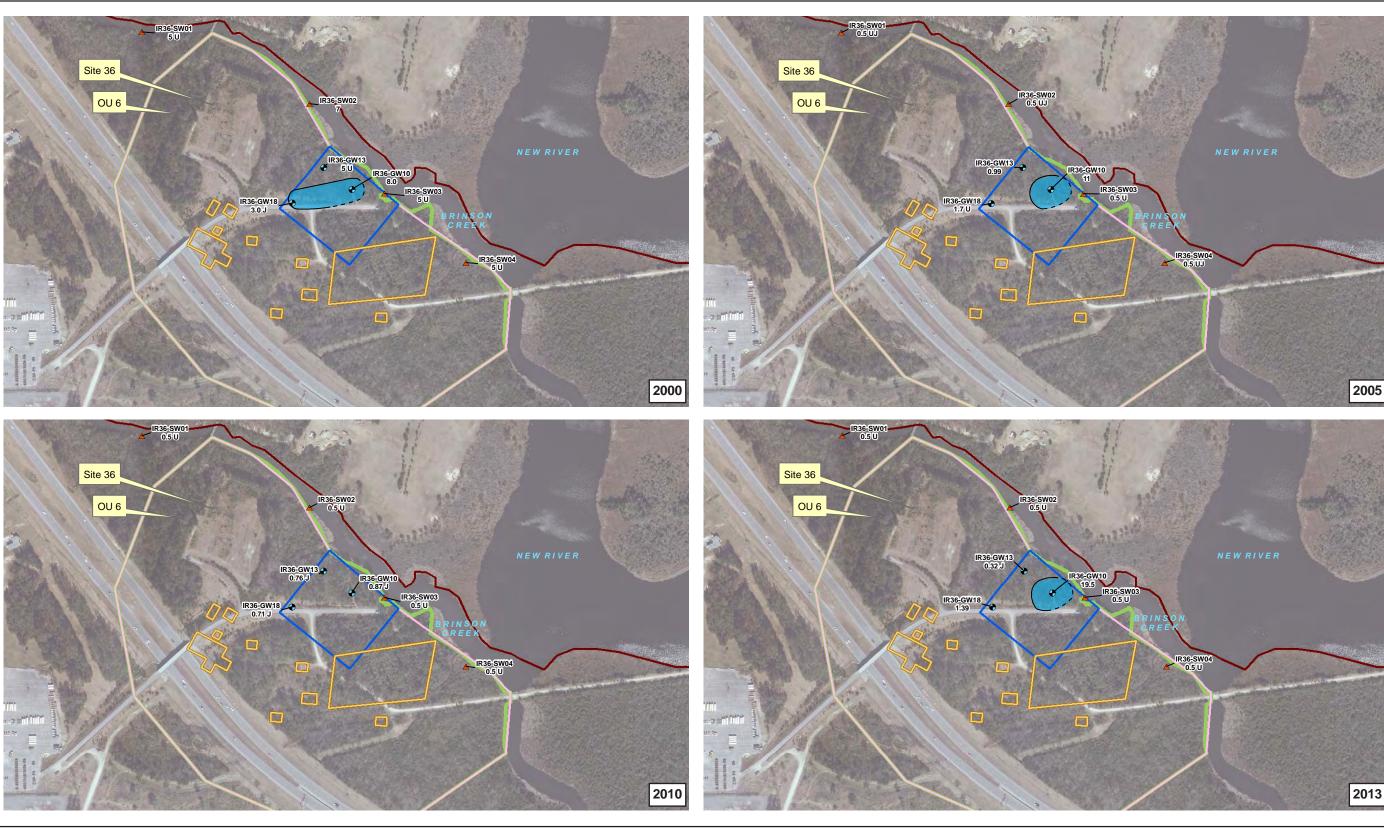


Figure 7-3 COC Trends in UCH Aquifer – Site 36 2015 Five-Year Review Camp Lejeune, North Carolina







Surficial Aquifer

Surface Water Sampling Locations

Operable Unit 6 Installation Boundary

TCE Extent (dashed where inferred) 3 μg/L - 30 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary (500 ft) Intrusive Activities Control Boundary (Groundwater)

Non-Industrial Use and Intrusive Activities (Soil) Control Boundary

μg/L - micrograms per liter U - analyte not detected above detection limit Intrusive Activites Control Boundary (Soil)

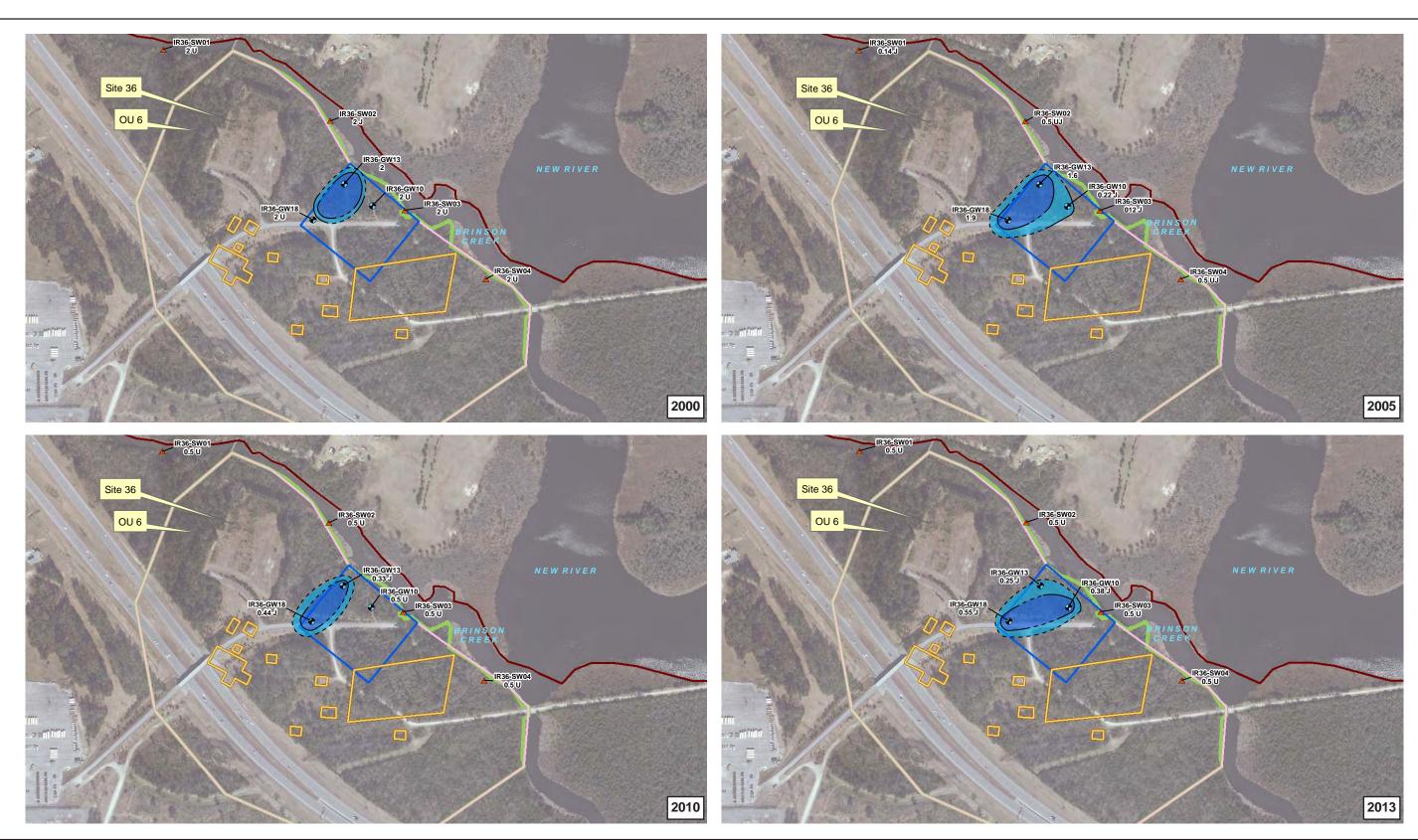
J - concentration is estimated

Notes: TCE - Trichloroethene TCE NCGWQS - 3 µg/L (April 2014) NCGWQS - North Carolina Groundwater Quality Standard

These plumes are based on the current LTM network at the time of each respective sampling event.

Figure 7-4 Site 36 Approximate Extent of TCE Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina





Surficial Aquifer

▲ Surface Water Sampling Locations Operable Unit 6

Installation Boundary

VC Extent (dashed where inferred)

0.03 μg/L - 0.3 μg/L 0.3 μg/L - 3 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary (500 ft)

Intrusive Activities Control Boundary (Groundwater)

Intrusive Activites Control Boundary (Soil) Non-Industrial Use and Intrusive Activities (Soil) Control Boundary

Notes: VC - Vinyl Chloride VC NCGWQS - 0.03 µg/L (April 2014) NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter U - analyte not detected above detection limit

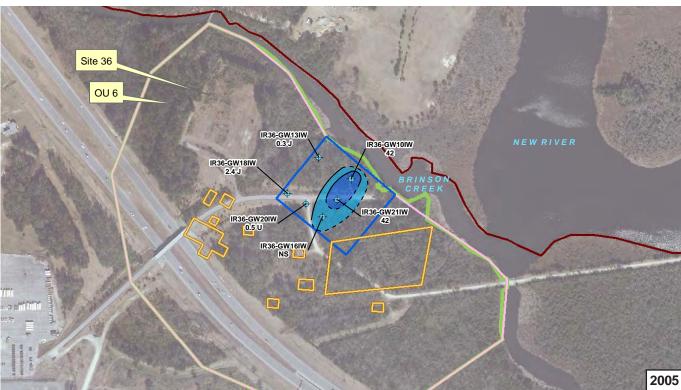
J - concentration is estimated

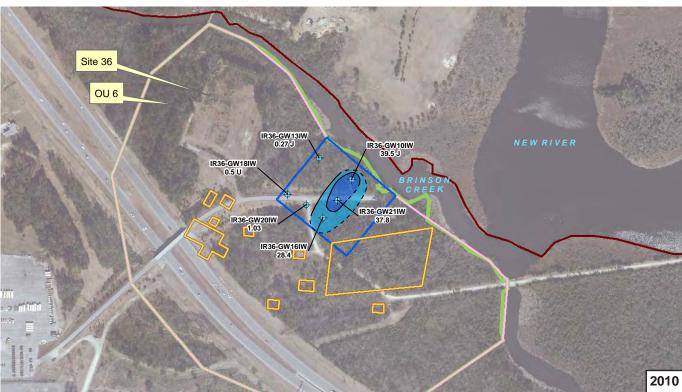
These plumes are based on the current LTM network at the time of each respective sampling event.

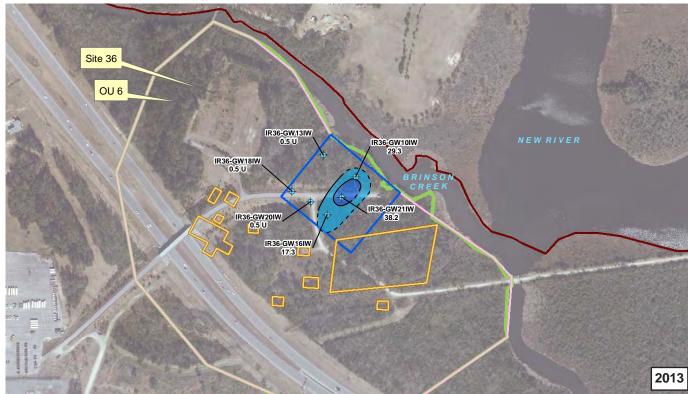
Figure 7-5 Site 36 Approximate Extent of Vinyl Chloride
Exceedances in the Surficial Aquifer
2015 Five-Year Review
Camp Lejeune North Carolina











Upper Castle Hayne Aquifer

Surface Water Sampling Locations Operable Unit 6 Installation Boundary

TCE Extent (dashed where inferred)

3 μg/L - 30 μg/L 30 μg/L - 300 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary (500 ft)

Intrusive Activities Control Boundary (Groundwater)

Intrusive Activites Control Boundary (Soil)

Non-Industrial Use and Intrusive Activities (Soil) Control Boundary

Notes: TCE - Trichloroethene

TCE NCGWQS - 3 µg/L (April 2014) NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter U - analyte not detected above detection limit

J - concentration is estimated

These plumes are based on the current LTM network at the time of each respective sampling event.

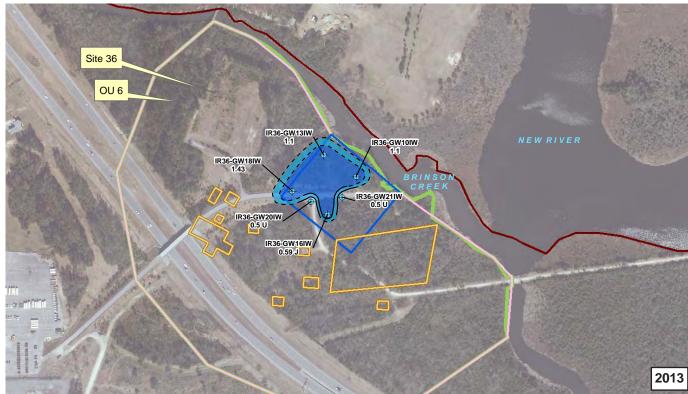
Figure 7-6 Site 36 Approximate Extent of TCE Exceedances in the UCH Aquifer 2015 Five-Year Review Camp Lejeune North Carolina











Upper Castle Hayne Aquifer

Operable Unit 6 Installation Boundary

VC Extent (dashed where inferred) 0.03 μg/L - 0.3 μg/L

0.03 μg/L - 0.3 μg/L 3 μg/L - 30 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary (500 ft)

Intrusive Activities Control Boundary (Groundwater)

Intrusive Activites Control Boundary (Soil)

Non-Industrial Use and Intrusive Activities (Soil) Control Boundary

Notes: VC - Vinyl Chloride VC NCGWQS - 0.03 µg/L (April 2014) NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter U - analyte not detected above detection limit

J - concentration is estimated NS - not sampled

These plumes are based on the current LTM network at the time of each respective sampling event.

Figure 7-7 Site 36 Approximate Extent of Vinyl Chloride
Exceedances in the UCH Aquifer
2015 Five-Year Review Camp Lejeune North Carolina



Operable Unit 7 (Sites 1, 28, and 30)

8.1 Site History and Background

OU 7 is within the Mainside area of the Base (**Figure 1-2**). OU 7 consists of three sites (Sites 1, 28, and 30) that have been grouped together into one OU because of their unique characteristics of suspected waste (POL) and geographic location. Site 30, Sneads Ferry Road Fuel Tank Sludge Area, was closed with NFA in 1996 and is not included in the FYR.

Site 1 — French Creek Liquids Disposal Area is approximately 8 acres and has been used by several different mechanized, armored, and artillery units since the 1940s (Figure 8-1). Liquid wastes generated from vehicle maintenance were reportedly routinely poured onto the ground surface. The wastes were reported to be primarily POL; however, battery acid was also reportedly disposed of. The suspected POL and battery acid disposal areas are in the northern and southern portions of the site. The estimated quantity of POL waste disposed at the areas is between 5,000 and 20,000 gallons, and the quantity of battery acid waste is between 1,000 and 10,000 gallons.

1983	•IAS (Site 1, 28, & 30)	
1984- 1987	•Confirmation Study (Site 1, 28, & 30)	
1991	•Soil Assessment (Site 1)	
1993	•Groundwater Study (Site 1)	
1994- 1995	•RI/FS (Site 1, 28, & 30)	
1995- 1996	•PRAP and ROD (Site 1, 28, & 30)	
1996	•NFA (Site 30)	
1996- 2002	•LTM, LUCs (Site 1 & 28)	
2014	•LUCIP Update (Site 28)	
2015	•RACR (Site 1)	

Site 28 — **Hadnot Point Burn Dump** is approximately 17 acres and operated from 1946 to 1971 as a burn area for a variety of solid

wastes generated on the Base (**Figure 8-1**). Industrial waste, trash, oil-based paint, and construction debris were reportedly burned and then covered with soil. In 1971, the burn dump ceased operations and was graded and seeded with grass. The total volume of fill within the dump is estimated to be between 185,000 and 375,000 cubic yards.

8.2 Site Characterization

The findings from various investigations at OU 7 that are pertinent to the FYR are summarized in this section.

8.2.1 Physical Characteristics

• Surface Features – Site 1 consists of fenced-in buildings and parking areas. The northern area of the site contains two fenced-in areas that are associated with Buildings FC-120 and FC-134. Two surface water features influence drainage near the northern portion of the site (a sediment retention pond and a swampy area). The southern portion of Site 1 primarily consists of buildings, fences, parking lots, and storage areas. A drainage ditch is in the southernmost portion of Site 1 and empties into Cogdels Creek, which eventually discharges into the New River located approximately one mile west of Site 1.

Site 28 is located along the eastern bank of the New River and consists of two lawn and recreation areas. Picnic pavilions, playground equipment, and a stocked fish pond are located within the recreation area (Baker, 1995). The site is surrounded by wooded and marshy areas to the east and west, the Hadnot Point Sewage Treatment Plant to the north, and the New River to the west.

ES120414012346RAL 8-1

Geology and Hydrogeology – Subsurface conditions at OU 7 generally consist of Coastal Plain deposits
consisting of silty sands with thinly interbedded discontinuous layers of clay and silty clay. Surficial
groundwater flow at Site 1 flows west-northwest. Surficial groundwater flow at Site 28 flows toward Cogdels
Creek and the New River (Baker 1995).

8.2.2 Land Use

- Current Land Use Site 1 continues to serve as a vehicle and equipment maintenance/staging area. Most of
 Site 28 is used for recreation and physical training exercises. The former Hadnot Point Sewage Treatment
 Plant was partially located within the Site 28 boundary; the area is currently used as a construction material
 staging area.
- Future Land Use There are no anticipated changes in land use.

8.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 7 RI report (Baker, 1995a) and the OU 7 ROD (Baker, 1995b).

Site 1

- VOCs, SVOCs, pesticides, PCBs, and metals were detected in soil and VOCs, SVOCs, and metals were detected
 in the groundwater.
- An HHRA and ERA were completed for Site 1 as part of the RI. Potential unacceptable risks were identified for future residents from exposure to manganese and arsenic in groundwater, but were determined to be highly conservative and the risks were deemed to be low. Further, based on a comparison of site data to Base background levels and the site history, detections of metals at Site 1 did not appear to be the result of past disposal practices. Therefore, arsenic and manganese were not retained as COCs for Site 1. A slight ecological risk was identified to terrestrial vertebrate receptors via ingestion. However, the risk is expected to be low because of the low level of the exceedances of the terrestrial reference values (Baker, 1995b).

Site 28

- VOCs, SVOCs, pesticides, PCBs, and metals were detected in both soil and groundwater. Metals and pesticides were detected in sediment and metals were detected in surface water.
- An HHRA and ERA were completed for Site 28 as part of the RI. Potential unacceptable risks were identified for current and future child receptors from exposure to metals in soil, groundwater, and sediment from the New River. However, concentrations of metals in soil were just above the screening criteria; therefore, the risks associated with exposure to soils were deemed to be low and metals were not retained as COCs in soil. Potential unacceptable risks were identified for future adult receptors from exposure to metals in groundwater. The ERA concluded there were no unacceptable risks to the environment (Baker, 1995b).

8.3 Remedial Action Objectives

The ROD addressing groundwater and soil at OU 7 was signed in 1996 (Baker, 1996). The RAOs identified for OU 7 are:

- Prevent current and future exposure to contaminated groundwater.
- Protect uncontaminated water for future potential use.

The cleanup levels for OU 7 are presented in **Table 8-1**.

8.4 Remedial Actions

The OU 7 RA components and expected outcomes are summarized in **Table 8-2**. The RA for OU 7 includes the following major components:

LTM for VOCs (Site 1) and metals (Site 28) in groundwater.

8-2 ES120414012346RAL

- LUC implementation for groundwater (Site 1 and 28) as follows:
 - Prohibit non-industrial land use, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.
 - Restrict intrusive activities below the water table within the vicinity of the estimated impacted groundwater extent.
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the aquifers (surficial and Castle Hayne) within 1,000 feet of the estimated impacted groundwater extent.
 - Prohibit the installation of any well, except for the purpose of monitoring, within the site boundaries.

8.4.1 Remedy Implementation

Long-term Monitoring and Land Use Controls

LTM at OU 7 was implemented in July 1996. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002). The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

8.4.2 Remedy Operation and Maintenance

Long-term Monitoring

The LTM Program at Site 1 included semi-annual sampling of eight monitoring wells for VOCs analysis. In January 2001, LTM was considered complete at Site 1 when the COCs were below cleanup levels for four consecutive rounds (CH2M HILL and Baker, 2002).

The LTM Program at Site 28 included semi-annual sampling of seven monitoring wells for metals analysis. In July 2000, LTM data for Site 28 suggested that the fluctuating lead concentrations observed were due to seasonal influences (i.e., groundwater table fluctuations) at an isolated location. The fluctuating lead concentrations were evaluated in monitoring well IR28-MW07 and the study concluded that the metals are leaching during periods of high groundwater elevations and it is believed that this cycle will continue indefinitely. Site 28 was recommended for removal from the LTM program and in 2002 a close-out report was prepared to document the completion of LTM (CH2M HILL and Baker, 2002).

Land Use Controls

LUCs at Site 1 were removed effective April 15, 2015 because groundwater was the only medium of concern at Site 1 and LTM is complete. The remedy completion was documented in a RACR (CH2M HILL, 2015).

LUCs were updated in 2014 at Site 28 to prevent potential unacceptable exposure to buried waste, based on historical site use and waste reportedly encountered during utilities installation along the southern bank of Orde Pond in 2012 (CH2M HILL, 2014). The LUCs were updated as follows: the intrusive activity control boundary (groundwater) was removed, the current aquifer use control boundary was maintained, the non-industrial LUC boundary was extended to encompass all former dump boundaries, and an intrusive activities control boundary (waste) was instituted to cover all former dump boundaries.

The LUCs are shown on **Figure 8-1** and summarized in **Table 8-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate the LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were identified during these inspections.

ES120414012346RAL 8-3

TABLE 8-3
OU 7 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
	Site 28		
Non-Industrial Use Control Boundary (Waste)	25.73	October 2014	September 30, 2014
Intrusive Activities Control Boundary (Waste)	25.73	October 2014	September 30, 2014
Aquifer Use Control Boundary (1,000 feet)	79.57	October 2014	September 30, 2014

8.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 8-4.

TABLE 8-4 2010 FYR OU 7 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status		
Groundwater LUCs remain in place and are not needed	Update LUCs to remove groundwater intrusive and use restrictions. (2012)	Completed in 2013. A LUCIP was completed for Site 28 (CH2M HILL, 2014). LUCs restricting groundwater intrusive activities and aquifer use at Site 28 were eliminated. LUCs prohibiting non-industrial use control, intrusive activities control,		
Current LUCs do not		and aquifer use control in the waste were added.		
prevent soil intrusive activities	Update LUCs to include intrusive restrictions for soil to prevent potential exposure to waste. (2012)	Since remedial goals have been met at Site 1, the remedy completion is being documented in a RACR (CH2M HILL, 2015).		
Monitoring wells remain in place	Abandon existing monitoring wells in accordance with NC Regulations. (2012)	Completed in 2012. Monitoring wells were abandoned at Sites 1 and 28 in 2012.		

8.5 Technical Assessment

Is the remedy functioning as designed?

Yes. Groundwater cleanup levels have been achieved and LTM has been discontinued for both sites. The remedy is complete at Site 1 and is documented in a RACR (CH2M HILL, 2015). At Site 28, LUCs restricting groundwater intrusive activities and aquifer use outside of the waste area have been removed and LUCs to restrict non-industrial land use, intrusive activities, and aquifer use were updated to reflect the extent of waste remaining in place (CH2M HILL, 2014).

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The cleanup levels for groundwater were identified as the more conservative of the Federal MCLs or NCGWQS at the time the ROD was signed. LTM was discontinued previously based on meeting the cleanup levels identified in the ROD. Since that time, the standard for TCE has been updated and is more conservative as listed in **Table 8-1**.

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 7 during the FYR.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs identified in the ROD, groundwater LTM is complete and considered protective (CH2M HILL and Baker, 2002). There have been changes in toxicity values for constituents detected in site media (Table 2-1). However, it is not expected that they would significantly change the results of the risk assessment, and many of the constituents detected at the site are inorganics, which were attributed to background conditions.

8-4 ES120414012346RAL

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

8.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 7 during this FYR.

8.7 Statement of Protectiveness

The remedy is complete at Site 1 and a RACR is being prepared to document completion. The remedy at Site 28 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through LUCs to restrict intrusive activities, non-industrial use, and aguifer use.

8.8 References

Baker. 1995. Remedial Investigation, Operable Unit No. 7 (Sites 1, 28, and 30). Marine Corps Base, Camp Lejeune. North Carolina. June.

Baker. 1996. Record of Decision, Operable Unit No. 7, Sites 1, 28, and 30. Marine Corps Base, Camp Lejeune. North Carolina. October.

Baker. 2002. Land Use Control Implementation Plans. Marine Corps Base Camp Lejeune, North Carolina. July.

CH2M HILL and Baker. 2002. Closeout Report. Operable Unit No. 7, Sites 1 & 28, Marine Corps Base Camp Lejeune, North Carolina. September.

CH2M HILL. 2014. Land Use Control Implementation Plan Update, Site 28, Operable Unit No. 7. Marine Corps Installation East – Marine Corps Base Camp Lejeune, North Carolina. October.

CH2M HILL. 2015. Remedial Action Completion Report, Operable Unit 7, Site 1. Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina. February.

ES120414012346RAL 8-5

TABLE 8-1

Cleanup Levels for OU 7 (Sites 1 and 28)

2015 Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels	Current Cleanup Level		
	COCS	(Baker, 1996)	Concentration	Reference	
	VOCs (Site 1)				
	Trichloroethene	5	3	NCGWQS	
Groundwater (μg/L)	Metals (Site 28)				
	Lead	15	15	NCGWQS/MCL	
	Manganese	50	50	NCGWQS	

Notes:

Shading indicates cleanup levels achieved/remedy complete per Closeout Report (CH2M HILL and Baker, 2002)

Cleanup Level Reference Dates:

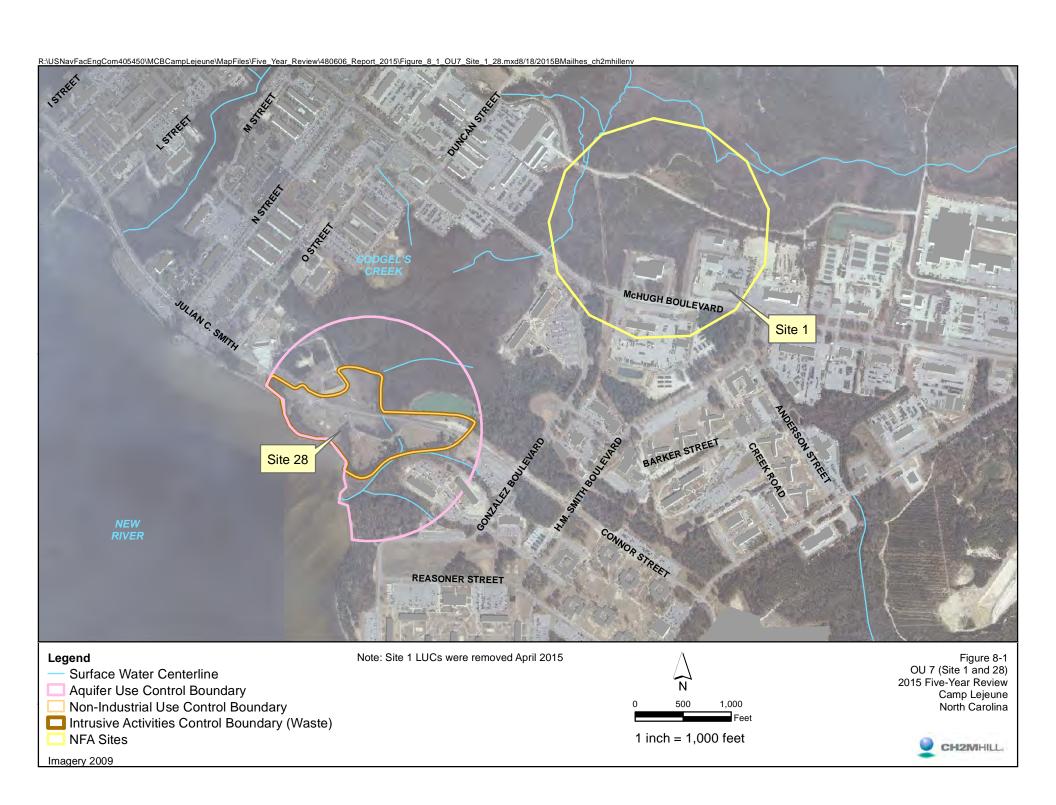
MCL (May 2009)

NCGWQS (April 2013)

TABLE 8-2
OU 7 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
1	Groundwater VOCs exceed MCL or			Prevent current and future exposure to contaminated groundwater.	LTM	LTM is complete, groundwater cleanup levels were achieved for four consecutive rounds of sampling. A RACR is being	UU/UE
		NCGWQS.	Protect uncontaminated water for		LUCs	prepared to close the site and remove the LUCs.	33,32
		Potential unacceptable	Industrial/		LTM	LTM is complete.	
	Groundwater	risks to future residential adult and children from exposure to metals in	Recreational	Prevent current and future exposure to groundwater that may be contaminated by waste in place.		Maintain aquifer use controls and monitor quarterly.	Non-Residential
28		groundwater.			LUCs	Aquifer use restrictions will continue to be implemented because waste remains inplace.	Land Use
	Waste	Potential unacceptable exposure to waste-in-place.		Prevent exposure to waste-in-place (identified post ROD).	LUCs	Maintain non-industrial and intrusive activities controls and monitor quarterly.	



Operable Unit 8 (Site 16)

9.1 Site History and Background

OU 8 is within the Camp Johnson area of the Base (Figure 1-2) and consists of Site 16.

Site 16 — Former Montford Point Burn Dump is approximately 4 acres in the Montford Point area of the Base (Figure 9-1). The dump was open from 1958 to 1972; however, unauthorized dumping may have occurred after closure. Trash from the surrounding housing area and buildings is suspected to have been burned and then covered with soil. Records indicate building debris, garbage, tires, and small amounts of waste oils were disposed at the site. Materials, including asbestos insulating material for pipes, were also dumped on

1983	·IAS
1994- 1996	•RI/FS
1995	•Groundwater and Soil Investigation
1996	•PRAP/ROD
2001- 2002	•RIP (LUCs)
2012	•ESD & Land Use Control Implementation Plan

the surface. The quantity of asbestos material was estimated at less than 1 cubic yard and removal of the asbestos was completed.

9.2 Site Characterization

The findings from various investigations at OU 8 that are pertinent to the FYR are summarized in this section.

9.2.1 Physical Characteristics

- Surface Features Site 16 is relatively flat and cleared. The area surrounding the site is heavily wooded with pine and hardwood forest. Northeast Creek is approximately 400 feet southeast of the site and flows in the southwesterly directions toward the New River. Surface drainage is in a southeast direction toward Northeast Creek.
- Geology and Hydrogeology Site 16 is primarily underlain by sands and silty sands with lenses and/or
 discontinuous layers of sand and clay, clay, and sandy clay (Baker, 1996a). Groundwater at Site 16 flows
 southeast, in the direction of Northeast Creek.

9.2.2 Land Use

- Current Land Use Site 16 is vacant and access by vehicles is prevented by a gate at the entrance to the site.
- Future Land Use There are no anticipated changes in land use.

9.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 8 RI (Baker, 1996a) and the OU 8 ROD (Baker, 1996b).

- Several pesticides were detected in soil and sediment. PCBs and SVOCs (primarily PAHs) were also detected in surface soil. Benzene and ethylbenzene were detected in one groundwater sample collected during the first round of groundwater sampling; however, VOCs were not detected in subsequent sampling.
- An HHRA and ERA were completed for OU 8. Potential unacceptable human health risks were identified for future
 residents due to the presence of PCBs, specifically Aroclor-1254, in soil. However, the maximum detected PCB
 concentration (2.1 parts per million [ppm]) was below the recommended cleanup level for PCBs of 10 to 25 ppm
 for industrial areas. No unacceptable ecological risks were identified for terrestrial or aquatic receptors.

ES120414012346RAL 9-1

9.3 Remedial Action Objectives

The ROD addressing soil and groundwater at OU 8 was signed on September 30, 1996 (Baker, 1996b). The selected remedy in the ROD was NFA because risks were considered minimal. However, LUCs were implemented by the Base in 2001 for planning purposes due to the site's past use as a dump. An ESD adding LUCs as the final remedy was signed on November 16, 2012 (CH2M HILL, 2012). The RAO identified for OU 8 based on the ESD is to prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.

9.4 Remedial Actions

The OU 8 RA components and expected outcomes are summarized in **Table 9-1**. The RA for OU 8 includes the following major components:

- LUC implementation for soil and groundwater as follows:
 - Prohibit the withdrawal and any use of groundwater, except for environmental monitoring, from the aquifers (surficial and Castle Hayne) within 1,000 feet of the site.
 - Prohibit intrusive activities below the shallow groundwater table.
 - Prohibit non-industrial land use within the site boundary, which includes restrictions on the construction
 of residential housing, hospitals, hotels, nursing homes, and day care facilities.

9.4.1 Remedy Implementation

LUCs were implemented in 2001 and 2002 (Baker, 2002). The LUCs were recorded with Onslow County as a notice of contamination and in the Base GIS and Master Planning.

9.4.2 Remedy Operation and Maintenance

LUCs were updated in 2014 at Site 16 based on a recommendation from the 2010 FYR to prevent potential unacceptable exposure to soil impacted by buried waste (CH2M HILL, 2014). The LUCs were updated to add the intrusive activities control boundary for soil within the same boundary as the non-industrial use control boundary for soil. The LUCs are shown on **Figure 9-1** and summarized in **Table 9-2**.

TABLE 9-2
OU 8 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Intrusive Activities Control Boundary (Soil)	2.1	August 2014	August 2014
Non-Industrial Use Activities Control Boundary (Soil)	2.1		
Intrusive Activities Control Boundary (Groundwater)	0.169	July 2002	February 2007
Aquifer Use Control Boundary (1,000 feet)	60.2		

Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate the LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were identified during these inspections.

9.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 9-3.

9-2 ES120414012346RAL

TABLE 9-3 2010 FYR OU 8 Recommendations/Follow-up Actions

Issues Recommendations (Milestone)		Date Completed/Current Status	
NFA was the selected remedy in the ROD	Submit an ESD to identify LUCs as the remedy. (2013)	Completed in 2012. An ESD was submitted in 2012 to document the LUCs as the remedy including the addition of an intrusive activities control boundary for soil to prevent exposure to waste in place (CH2M HILL, 2012).	
Current LUCs do not prevent soil intrusive activities Update LUCs to include intrusive restrictions for soil to prevent potential exposure to waste. (2012)		Completed in 2014. A LUCIP was drafted in 2013 and an updated Notice of Contaminated Site was filed with Onslow County real property records and the Base Master Plans will be updated (CH2M HILL, 2014).	

9.5 Technical Assessment

Is the remedy functioning as designed?

Yes. No RA was required; however, LUCs were implemented and remain in place to prohibit non-industrial land use, restrict intrusive activities below the water table, and prohibit aquifer use. LUCs were added to restrict intrusive activities within the extent of waste to prevent exposure.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes, the exposure assumptions and toxicity data are still valid. No ecological or human health risks were identified for OU 8; therefore, RAOs remain valid.

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 8.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria and some detected analytes (Table 2-1), the remedy to maintain LUCs restricts unauthorized activities that may result in exposure to impacted soil or groundwater under the hypothetical future residential land use. Thus, toxicity changes would not affect the protectiveness of the remedy.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

9.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 8 during this FYR.

9.7 Statement of Protectiveness

The remedy at OU 8 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit non-industrial land use and restrict intrusive activities within the waste disposal area, prohibit the withdrawal and any use of the groundwater, except for environmental monitoring, from the aquifers (surficial and Castle Hayne) within 1,000 feet of the site, and to restrict intrusive activities below the shallow groundwater table.

ES120414012346RAL 9-3

9.8 References

Baker. 1996a. Remedial Investigation Report, Operable Unit No. 8 (Site 16). Marine Corps Base Camp Lejeune, North Carolina. January.

Baker. 1996b. Record of Decision, Operable Unit No. 8 (Site 16). Marine Corps Base Camp Lejeune, North Carolina. April.

Baker. 2002. Land Use Control Implementation Plans. Marine Corp Base Camp Lejeune, North Carolina. July.

CH2M HILL. 2010. Five-Year Review. Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. August.

CH2M HILL. 2012. Explanation of Significant Difference Operable Units 8 (Site 16), 11 (Site 80), and 13 (Site 63). Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina. July.

C2HM HILL. 2014. Land Use Control Implementation Plan Site 16, Operable Unit No. 8. Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina. August.

9-4 ES120414012346RAL

TABLE 9-1
OU 8 Remedial Action Summary and Expected Outcomes

2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
16	Soil	Potential unacceptable risks from exposure to site media		Prevent exposure to waste due to the uncertainty of whether it would		Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	Industrial Land Use
16		based on site history as a waste disposal area.	•	present unacceptable risk should exposure occur.		Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring.	industrial Land USE



Operable Unit 10 (Site 35)

10.1 Site History and Background

OU 10 is within the Camp Geiger operations area of MCAS New River (Figure 1-2). OU 10 consists of Site 35.

Site 35 — Former Camp Geiger Fuel Farm is approximately 45 acres (Figure 10-1). The fuel farm included five 15,000-gallon ASTs, underground fuel transmission lines, a pump house, a fuel unloading pad, an OWS, and a distribution island. The ASTs were installed in 1945 as part of the original Camp Geiger construction. The fuel farm was active until it was decommissioned in the spring of 1995 to make way for the construction of the U.S. Highway 17 Bypass (Bypass). Several releases of fuel occurred during its 50-year operating period. A vehicle maintenance garage (former Building TC474) and weapons cleaning area were also present at the site (Figure 10-2).

10.2 Site Characterization

The findings from various investigations at OU 10 that are pertinent to the FYR are summarized in this section.

10.2.1 Physical Characteristics

- Bypass, which is at a higher elevation of the Bypass, which is at a higher elevation than the rest of the site, the ground surface at Site 35 is generally flat. The majority of the site consists of roadways, buildings, former building foundations, and several large parking areas. The eastern portion of the site, beginning at the Bypass, is heavily wooded and slopes down towards Brinson Creek. Storm water across the developed portion of the site is conveyed via manmade drainage ditches, storm drains, and catch basins, and discharges to Brinson Creek and its tributaries, where it then flows southeast into the New River.
- Geology and Hydrogeology Subsurface conditions consist of typical Coastal Plain

1505	1/1/3	
1984- 1987	•Confirmation Study)
1990	•Focused FS	
1992- 1993	*Comprehensive Site Assessment)
1993- 1994	•Interim Remedial Action RI/FS (Soil)	
1994	•Interim ROD (Soil)	
1995	•RI, Interim FS and ROD (Surficial Groundwater)	7
1995- 1996	•Supplemental Groundwater Investigation	
1996	•In situ AS Treatability Study	
1995- 1997	•Interim Removal Action (Soil)	
1999- 2004	•LTM	
1998- 2002	Natural Attenuation Evaluation	
2002- 2003	•Hot Spot Characterization	7
2003	•Technical Evaluation	
2005- 2008	•Supplemental RI	
2006	•ISCO Pilot Study	
2006- 2008	•NTCRA (Groundwater)	
2009	2009 •FS (Groundwater)	
2009	•PRAP/ROD (Groundwater)	
2007- 2013	Basewide VI Evaluation)
2010- Present	•LTM	
2010- 2011	•RIP and Interim RACR (AS)	
2013	•AS system off - February	7

deposits, including fine-to-medium grained sands, clayey sands, and partially indurated sediments. Groundwater is typically encountered at depths ranging from approximately 1 foot bgs in the swampy area east of the Bypass to 11 feet bgs in the former fuel farm area. In general, the groundwater flow direction within the surficial, UCH, and MCH aquifers is to the northeast towards Brinson Creek and the New River. The Castle Hayne aguifer confining unit observed between the surficial and Castle Hayne aguifers across much of

ES120414012346RAL 10-1

the Base is either not present or is laterally discontinuous at Site 35 and a hydraulic connection exists between the surficial and UCH aquifers (CH2M HILL 2009a).

10.2.2 Land Use

- **Current Land Use** Portions of Site 35 are currently used by the Camp Geiger School of Infantry. Armory operations, several warehouses, general storage buildings, and troop barracks occupy the area.
- Future Land Use There are no anticipated changes in land use.

10.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the Supplemental RI (CH2M HILL, 2009a) and ROD (CH2M HILL, 2009b).

- Petroleum hydrocarbons were detected in soil and petroleum hydrocarbons and CVOCs were detected in groundwater at OU 10 at concentrations above screening levels during the initial RI (Baker, 1994 and 1995). As a result, IRAs to address soil and surficial aquifer groundwater were completed and are discussed in Section 10.2.4. Pesticides and metals were reported in sediment samples collected from Brinson Creek. During the Supplemental RI, completed after the IRAs were initiated, groundwater in the surficial and UCH aquifers contained VOCs at concentrations exceeding the NCGWQS or MCL (CH2M HILL, 2009a).
- An HHRA and ERA were completed as part of the initial and supplemental RIs. The HHRA concluded that site-related impacts do not pose an unacceptable risk to human health based on current and future non-residential site use. If the site is developed for future residential use, there may be potential unacceptable risks to future residential receptors through potable use of groundwater (associated with VOCs) and VI. The ERA identified minimal potential risks associated with pesticides and metals in sediment; however, they were determined not to be site-related as they were not attributed to historical site activities. Therefore, it was concluded that there were no site-related risks to terrestrial and aquatic receptors related to Site 35.

10.2.4 Interim Removal Actions

Interim RODs to address soil and surficial aquifer groundwater were signed in September 1994 (Baker, 1994), and September 1995 (Baker, 1995), respectively. The IRAs for Site 35 included the following major components:

- Excavation and offsite disposal of VOC-contaminated soil: From September 1995 to May 1996 approximately
 15,700 tons of petroleum-contaminated soil were excavated for offsite disposal (OHM, 1997). Concentrations
 of COCs in soil confirmation samples were below cleanup levels; therefore, the potential unacceptable risks
 from exposure to soil were effectively removed.
- Air sparging (AS) using a vertical trench to address VOCs in surficial aquifer groundwater: An AS trench was
 installed in 1998 to address the northeast portion of surficial aquifer groundwater plume near the former fuel
 farm. The AS trench operated until 2009 when the final RA was implemented to address site-wide
 groundwater and it was dismantled.

Additional removal actions and pilot studies were completed in preparation of the FS to address site-wide groundwater, as follows:

- From December 2003 to July 2005, a pilot study was conducted to evaluate the effectiveness of ISCO in an area of groundwater near the former Fuel Farm. The pilot study involved injection of approximately 26,000 gallons of modified Fenton's reagent followed by injection of approximately 19,400 gallons of potassium permanganate solution. The pilot study achieved 80 to 98 percent reduction of TCE and 72 to 85 percent total VOC reduction within the study area (CH2M HILL, 2006).
- From May 2007 to June 2008 a non-time-critical removal action (NTCRA) consisting of approximately 50,520 pounds of an ERD substrate (50:50 emulsified vegetable oil [EVO] and lactate mix) was injected via DPT in an area of groundwater with concentrations of TCE greater than 100 μg/L, bounded by Fifth, F, Fourth, and C Streets. The target depth was 20 to 47 feet bgs. Results of the NTCRA monitoring indicated that TCE in

10-2 ES120414012346RAL

surficial aquifer groundwater was decreased by 54 percent and DCE decreased by 69 percent. However, deeper concentrations of TCE and DCE were not reduced significantly (CH2M HILL, 2008).

10.3 Remedial Action Objectives

The ROD addressing groundwater at OU 10 was signed in November 2009 (CH2M HILL, 2009b). The RAOs identified for OU 10 are:

- Restore groundwater quality at Site 35 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A North Carolina Administrative Code (NCAC) 02L.0201.
- Prevent human ingestion of water containing COCs (benzene, 1,1,2,2-PCA, PCE, TCE, cis-1,2-DCE, and VC) at concentrations exceeding NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.
- Minimize migration of COCs in groundwater to surface water.

The cleanup levels for OU 10 are presented in **Table 10-1**.

10.4 Remedial Actions

The OU 10 RA components and expected outcomes are summarized in **Table 10-2**. The RA for OU 10 includes the following major components:

- AS using a horizontal directionally drilled (HDD) well to address COCs.
- LTM of groundwater to evaluate the effectiveness of the AS system and MNA outside of the active treatment area and after active treatment is complete.
- LUC implementation for groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the aquifers (surficial and Castle Hayne) within 1,000 feet of the estimated impacted groundwater extent.
 - Maintain the integrity of any existing or future monitoring or treatment system at the site.

10.5 Remedy Implementation

Air Sparging

The AS system includes a 1,080-foot long HDD well with a 500-foot well screen, installed to 50 feet bgs. The AS HDD well was designed to deliver air at a rate of approximately 180 standard cubic feet per minute (scfm) across the well screen, promoting mass transfer of CVOCs and/or aerobic biodegradation of benzene and VC. Construction details for the AS system can be found in the IRACR (Shaw, 2011).

Long-term Monitoring and Land Use Controls

LTM began in 2011 and is ongoing as described in the following section. LUCs were implemented at OU 10 in 2010 (CH2M HILL, 2010). The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

10.5.1 Remedy Operation and Maintenance

Air Sparging

The AS system operated from August 2010 to February 2013. The system operated at 180 scfm with the exception of down times during sampling and system repairs in October 2012. The system was turned off when 71 percent total VOC reduction in source area wells and 75 percent total VOC reduction in UCH monitoring wells within 100 feet of the sparging well were achieved and Biochlor modeling showed current concentrations to be protective of Brinson Creek. The system was prepared for a period of inactivity and left in place in the event that it would need to be turned on again (rebound). While the AS was operating, performance monitoring included

ES120414012346RAL 10-3

quarterly sampling of 3 surficial, 6 UCH, and 1 MCH aquifer monitoring wells for VOC analysis. A soil gas probe was installed and sampled quarterly for VOC analysis during operation to monitor potential VI risks to the nearest Building G560. During AS operation, soil gas data did not exceed the VI screening levels.

Monitored Natural Attenuation

MNA at Site 35 initially consisted of collecting groundwater samples from 14 surficial, 18 UCH, and 5 MCH aquifer monitoring wells for VOCs. After the AS system was turned off, the MNA network was optimized and currently includes 12 surficial, 16 UCH, 5 MCH monitoring wells. Samples are analyzed annually for VOCs and every five years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. The use of PDBs was initiated for VOC sampling to minimize generation of remediation-derived waste, equipment use, and overall field efforts when NAIP sampling is not occurring (CH2M HILL, 2014a).

Sampling locations are shown on **Figure 10-1**. The annual cost of MNA at OU 10 is approximately \$65,000.

Land Use Controls

Current LUCs are shown on **Figure 10-1** and summarized in **Table 10-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

TABLE 10-3
OU 10 Land Use Control Summary

LUC Boundary	Estimated Area	Most Current	Onslow County
	(Acres)	LUCIP Date	Registration Date
Aquifer Use Control Boundary	178.6	May 2010	August 2010

10.5.2 Progress since the 2010 Five-Year Review

Additionally, issues identified during the 2010 FYR and follow-up actions are summarized in **Table 10-4**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 10-2**.

TABLE 10-4
2010 FYR OU 10 Recommendations/Follow-up Actions

Issues	Recommendations (Milestones)	Date Complete/Current Status
Potential for VI pathway	Evaluate and mitigate VI pathway during construction planning. (Ongoing)	Ongoing. The VI pathway was evaluated at Buildings G480, G521, G530, G531, G532, and G533. There is no unacceptable risk from VI based on current land use (CH2M HILL, 2009c, 2011, 2015). If buildings are planned for construction in the vicinity of the VOC groundwater plume, the potential for a VI pathway is evaluated and mitigated if needed. Base Master Planning maintains current groundwater plume data in the GIS, and all construction projects on Base go through environmental review.

10.6 Technical Assessment

Is the remedy functioning as designed?

Yes. Based on decreasing concentrations observed during air sparge system monitoring and subsequent site-wide MNA sampling, the remedy is functioning as designed. Performance metrics were met for the AS system and it was shut off in 2012. LUCs are in place to prevent exposure to groundwater COCs at concentrations above cleanup levels.

10-4 ES120414012346RAL

Figures 10-3 through **10-8** show TCE, cis-1,2-DCE, and VC concentrations in the surficial and UCH aquifers at the time of remedy selection (2008), the event immediately before the AS system was turned off (2012), and the most recent sampling event (2013). **Figures 10-9** and **10-10** show benzene in the surficial and UCH aquifer, respectively, from 2009, 2012, and 2013.

Air Sparging

At the time of shut down (2012), TCE and cis-1,2-DCE in the samples collected from UCH aquifer wells had decreased significantly. VC in the UCH aquifer samples initially increased, most likely a result of an expanded well network in the source area and reductive dechlorination of TCE and cis-1,2-DCE. Since the system was shut down, concentrations of COCs have continued to attenuate, indicating that rebound does not appear to be occurring.

Long-term Monitoring

Although the well network has changed since 2008, samples from surficial aquifer wells IR35-MW47 and IR35-MW55 (located along the leading edge of the plume) show decreasing concentrations of TCE and cis-1,2-DCE (Figure 10-3 and 10-4). Concentrations of VC in the surficial aquifer increased from 2008 to 2012 but decreased between 2012 and 2013 in the vicinity of IR35-MW14 (Figure 10-5). The former AS trench was located in the general vicinity of IR35-MW14 and the difference from 2008 and 2012 may be a result of system shutdown and reductive dechlorination of TCE and cis-1,2-DCE. Concentrations of TCE and cis-1,2-DCE decreased in the UCH aquifer (Figures 10-6 and 10-7) and concentrations of VC initially increased from 2008 to 2012 but have decreased since 2012 (Figure 10-8). The increase in VC may be from reductive dechlorination of parent products. Benzene concentrations are stable in both aquifer zones (Figure 10-9 and 10-10).

In the southern area of Site 35, COCs are stable to slightly increasing. Because the overall change in concentration at IR35-MW92IW is relatively low (approximately 20 μ g/L over 10 years) and conditions for reductive dechlorination at IR35-MW92IW are generally favorable, continued monitoring and re-evaluation during LTM and the next FYR is recommended.

A summary of NAIP data is provided in **Table 10-5**. Conditions in the surficial aquifer and the UCH aquifer are generally favorable for reductive dechlorination. One year after the AS was turned off, geochemical parameters in the UCH aquifer appear to have returned to pre-treatment conditions. Favorable indicators for reductive dechlorination included ORP (negative or less than 50 mV), nitrate (low or not detected), ferrous iron (measurable levels), and sulfate (not detected or low concentrations). Elevated alkalinity in the surficial aquifer provides buffering capacity during degradation. TOC in both aquifer zones was low, which may be limiting for microbial growth.

Protection of Brinson Creek

Concentrations of TCE in the surficial and UCH aquifer do not exceed NCSWQS (30 μ g/L) in the samples immediately upgradient from Brinson Creek. However, concentrations of VC exceed the NCSWQS (2.4 μ g/L) and 10 times the NCSWQS (24 μ g/L) in the sample collected from IR35-MW62 (35.7 μ g/L, an increase from 18.1 μ g/L in 2012) located approximately 25 feet upgradient of Brinson Creek (**Figure 10-5**). Although downstream surface water samples collected as part of the LTM program at Site 36 (located approximately one-half mile downstream) do not exceed NCSQWS for Site 36 COCs (which includes TCE and VC), monitoring closer to Site 35 may be warranted because concentrations are greater than 10 times the NCSWQS for VC. Data collected during the 2015 LTM sampling was below 10 times the NCSWQS in surficial aquifer samples collected immediately upgradient to Brinson Creek and monitoring and evaluating potential impacts will be included as part of the LTM program.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The final ROD identified the cleanup levels for groundwater as the more conservative of the Federal MCLs or NCGWQS, which are still valid. In 2010, the remedial standards for three chemicals (1,1,2,2- PCA, TCE, and VC) were updated to the current NCGWQS, which reflects a slight increase in the cleanup level compared to the standards used in the final ROD as listed in **Table 10-1**.

ES120414012346RAL 10-5

Changes in Exposure Pathways: Although no current significant pathway of concern for VI was identified during the Basewide VI studies (CH2M HILL, 2009c, 2011 and 2014), consideration of the VI pathway is recommended during construction planning within 100 feet of VOC-impacted groundwater.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs and other constituents detected in site media (Table 2-1), the remedy to maintain LUCs restricts unauthorized activities which may result in exposure to groundwater until groundwater reduction to levels that allow for UU/UE. Thus, toxicity changes would not affect the protectiveness of the remedy.

An RSL was established for 1,4-dioxane. In 2002, USEPA collected groundwater samples at Site 35 to confirm the presence or absence of 1,4-dioxane. Analytical results were below detection limits (**Attachment C**).

Has any other information come to light that could question the protectiveness of the remedy?

Yes. The VI pathway has the potential to become complete at OU 10 and an RAO and LUCs should be added to include mitigating exposure via this pathway. VC in surficial groundwater samples collected upgradient to Brinson Creek exceeds 10 times the NCSWQS.

10.7 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 10 are summarized in Table 10-6.

TABLE 10-6
OU 10 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party	Oversight	Milestone	Affects Protectiveness (Y/N)	
		Responsible	Agency	Date -	Current	Future
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI)	Navy/Base	USEPA/State	6/30/2016	N	Y

10.8 Statement of Protectiveness

The remedy for groundwater at OU 10 is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled through LUCs for groundwater. The Base maintains all current COC plumes in GIS and Master Planning processes to prevent unacceptable exposure for potential VI pathways. MNA is ongoing to monitor groundwater COCs and LUCs to prohibit aquifer use and prevent exposure to COCs are in place until cleanup levels are achieved.

10.9 References

Baker. 1994. Soil Interim Record of Decision for Operable Unit No. 10 (Site 35), Marine Corps Base Camp Lejeune, North Carolina. August.

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CH2M HILL. 2009a. Supplemental Remedial Investigation, Site 35 – Operable Unit No. 10, Camp Geiger Area Fuel Farm. Marine Corps Base Camp Lejeune, North Carolina. March.

10-6 ES120414012346RAL

CH2M HILL, 2009b. *Record of Decision, Operable Unit 10, Site 35. Marine Corps Base Camp Lejeune, North Carolina*. November.

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CH2M HILL, 2012. Long-Term Monitoring Report Fiscal Year 2011. MCIEAST-MCB CAMLEJ, Jacksonville, North Carolina. November.

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ES120414012346RAL 10-7

TABLE 10-1

Cleanup Levels for OU 10 (Site 35)

2015 Five-Year Review

Camp Lejeune, North Carolina

Media	cocc	ROD Cleanup Levels	Current Cle	eanup Level
iviedia	COCs	(CH2M HILL, 2009)	Concentration	Reference
	VOCs	-		
	1,1,2,2-Tetrachloroethane	0.17	0.2	NCGWQS
	Benzene	1	1	NCGWQS
Groundwater (μg/L)	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	Tetrachloroethene	0.7	0.7	NCGWQS
	Trichloroethene	2.8	3	NCGWQS
	Vinyl chloride	0.015	0.03	NCGWQS

Cleanup Level Reference Dates:

MCL (May 2009)

NCGWQS (April 2013)

TABLE 10-2
OU 10 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
	Potential unacceptable ris		Restore groundwater quality at Site 35 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Potential unacceptable risks to Restore groundwater quality at Site 35 to wells demonstrating an asyl achieving the target 75% reprotectiveness of Brinson C through fate and transport of the system for 3 years. Performance metrics were a discontinued in February 20	AS until a reduction of COC concentrations of 75% in source area wells, COC reductions in source area wells demonstrating an asymptotic trend prior to achieving the target 75% reduction, and/or protectiveness of Brinson Creek is demonstrated through fate and transport modeling, or operation of the system for 3 years. Performance metrics were met and AS was discontinued in February 2013.			
35	future residents from exposure to VOCs in groundwater.	to surface water.	MNA	Implement groundwater MNA to monitor VOC concentrations and migration to surface water until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	UU/UE		
	Prevent human ingestion of water containing COCs (benzene, 1,1,2,2-PCA, PCE, TCE, cis-1,2-DCE, and VC) at concentrations exceeding NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.		LUCs	Maintain aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.			
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent future exposure to COCs in indoor air via the VI pathway.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	

Shading indicates Risks/Basis of Action resulting from changing site conditions, exposure pathways, or assumptions that were not present at the time of the ROD. The proposed RAO, Remedy Component, and Performance Metric are included.

TABLE 10-5
Site 35 Summary of NAIPs - December 2013
2015 Five-Year Review

Camp Lejeune, North Carolina

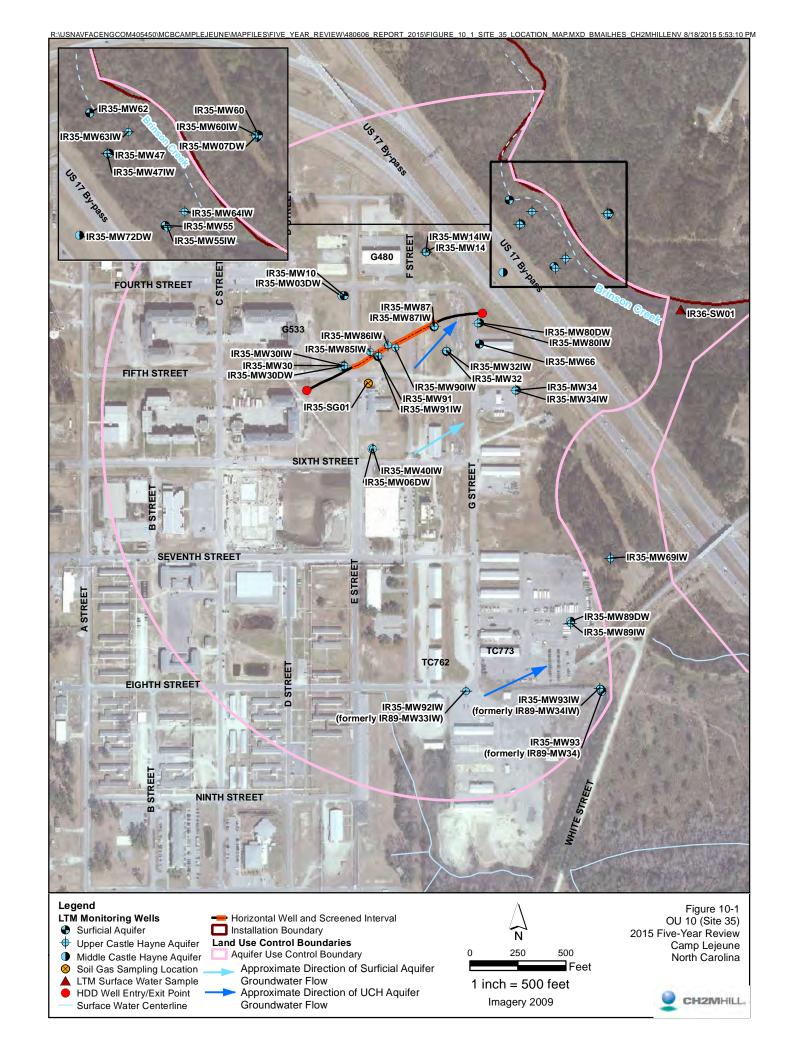
Indicator Parameter	Range of Results	Condition for favorable reductive pathway
Surficial Aquifer (within plume area)	•	
ORP (mV)	-81.6 to 223	Less than +50 mV (favorable) Less than -100 mV (ideal)
DO (mg/L)	0.18 to 1.39	Less than 1.0 mg/L
Nitrate (mg/L)	0	Less than 1.0 mg/L
Ferrous Iron (mg/L)	0 to 4	Measurable Levels
Sulfate (mg/L)	12.5 to 173	Less than 20 mg/L
Alkalinity (mg/L)	19.6 to 293, average 209	2x Above ¹ Background (94)
Chloride (mg/L)	5.46 to 17.5, average 11	2x Above ¹ Background (9.2)
Methane (μg/L)	6.58 to 6,970	>500 μg/L
Total Organic Carbon (mg/L)	1.33 to 4.86	>20 mg/L
Upper Castle Hayne Aquifer (Northern P	Plume)	
ORP (mV)	-343.2 to -4.8	Less than +50 mV (favorable) Less than -100 mV (ideal)
DO (mg/L)	0.11 to 2.21	Less than 1.0 mg/L
Nitrate (mg/L)	0 to 4	Less than 1.0 mg/L
Ferrous Iron (mg/L)	0 to 3.6	Measurable Levels
Sulfate (mg/L)	4.47 to 930	Less than 20 mg/L
Alkalinity (mg/L)	194 to 362, average 282	2x Above ¹ Background (259)
Chloride (mg/L)	7.8 to 122, average 27	2x Above ¹ Background (21)
Methane (μg/L)	1.19 to 1,030	>500 μg/L
Total Organic Carbon (mg/L)	1.29 to 3.63	>20 mg/L
Upper Castle Hayne Aquifer (IR35-MW9	2IW)	
ORP (mV)	-38.2	Less than +50 mV (favorable) Less than -100 mV (ideal)
DO (mg/L)	0.41	Less than 1.0 mg/L
Nitrate (mg/L)	0	Less than 1.0 mg/L
Ferrous Iron (mg/L)	1.6	Measurable Levels
Sulfate (mg/L)	24.7	Less than 20 mg/L
Alkalinity (mg/L)	244	2x Above ¹ Background (259)
Chloride (mg/L)	11.8	2x Above ¹ Background (21)
Methane (μg/L)	1.19	>500 μg/L
Total Organic Carbon (mg/L)	1.4	>20 mg/L
Middle Castle Hayne Aquifer (IR35-MW)	03DW)	
ORP (mV)	180	Less than +50 mV (favorable) Less than -100 mV (ideal)
DO (mg/L)	0.44	Less than 1.0 mg/L
Nitrate (mg/L)	0	Less than 1.0 mg/L
Ferrous Iron (mg/L)	1.2	Measurable Levels
Sulfate (mg/L)	1.01	Less than 20 mg/L
Alkalinity (mg/L)	223	2x Above ¹ Background (208)
Chloride (mg/L)	21.6	2x Above ¹ Background (35)
Methane (μg/L)	90.9	>500 μg/L
Total Organic Carbon (mg/L)	1.54	>20 mg/L

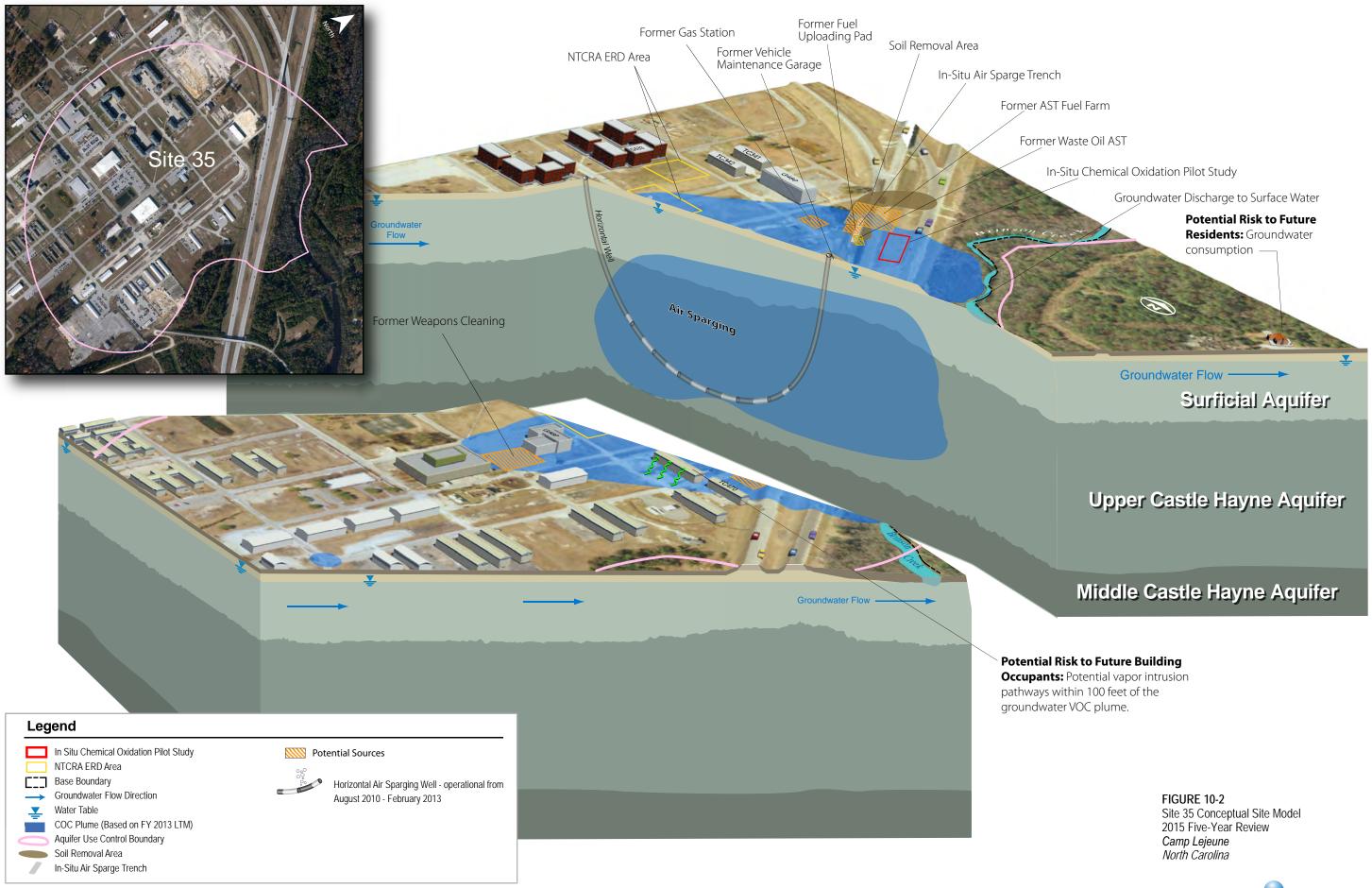
Notes:

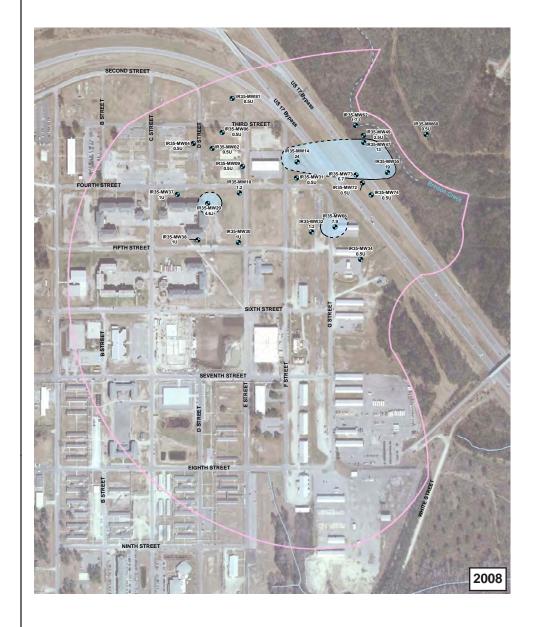
Surficial - IR35-MW93, MW34, and MW60,

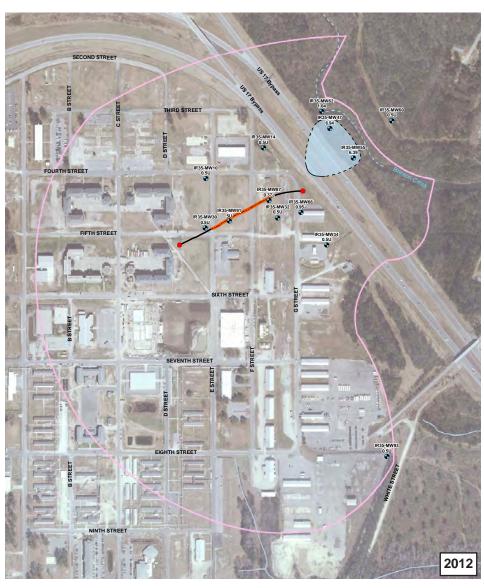
Upper Castle Hayne Aquifer - IR35-MW60IW, -MW69IW, -MW89IW, and -MW93IW Middle Castle Hayne Aquifer - IR35-MW06DW, -MW07DW, -MW30DW, and -MW93DW

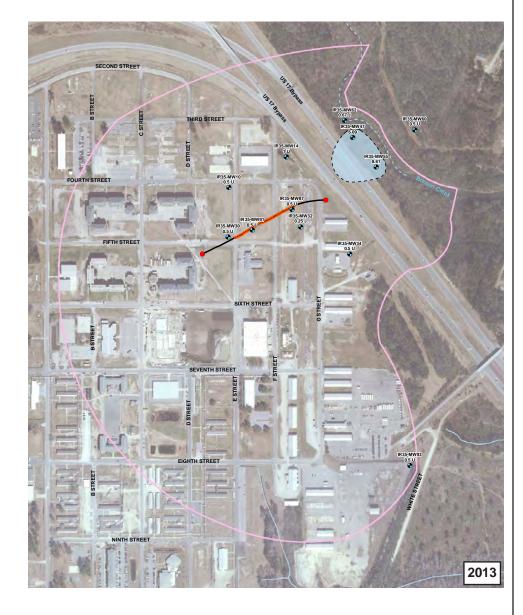
¹Background data from monitoring wells outside of historical plume area:











- Surficial Aquifer Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval

TCE Extent (dashed where inferred)

3 μg/L - 30 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Notes:

TCE - Trichloroethene

TCE NCGWQS - 3 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

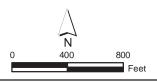
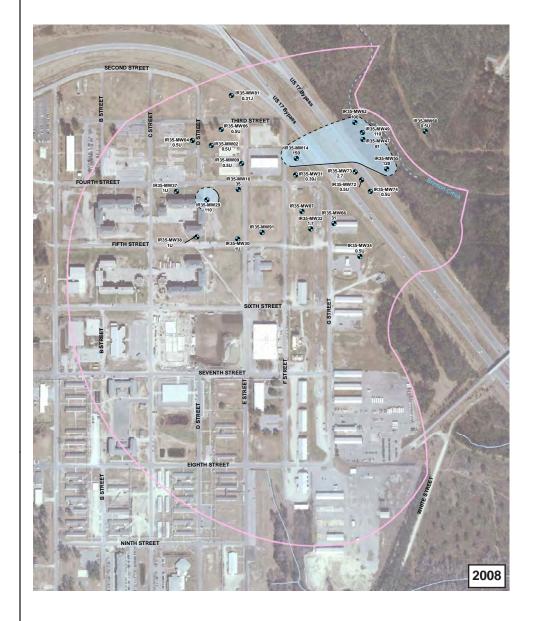
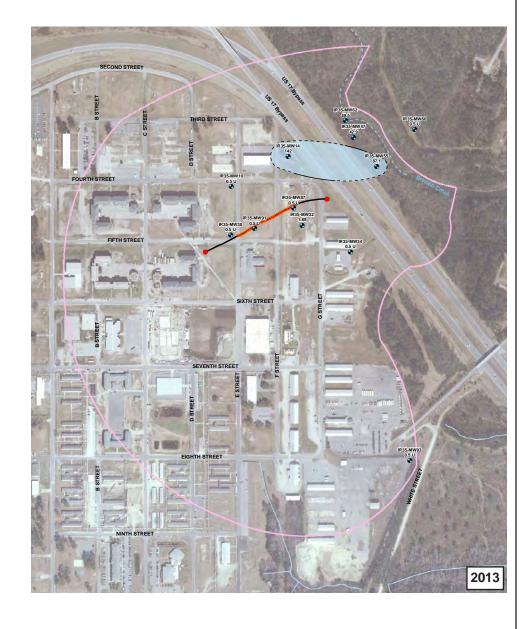


Figure 10-3 Site 35 Approximate Extent of TCE
Exceedances in the Surficial Aquifer
2015 Five-Year Review
Camp Lejeune North Carolina









- Surficial AquiferSurface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval
- cis-1,2-DCE Extent (dashed where inferred)
- 70 μg/L 700 μg/L
- Land Use Control Boundaries
- Aquifer Use Control Boundary

Notes:

DCE - Dichloroethene

cis-1,2-DCE NCGWQS - 70 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard $\mu g/L$ - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

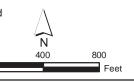
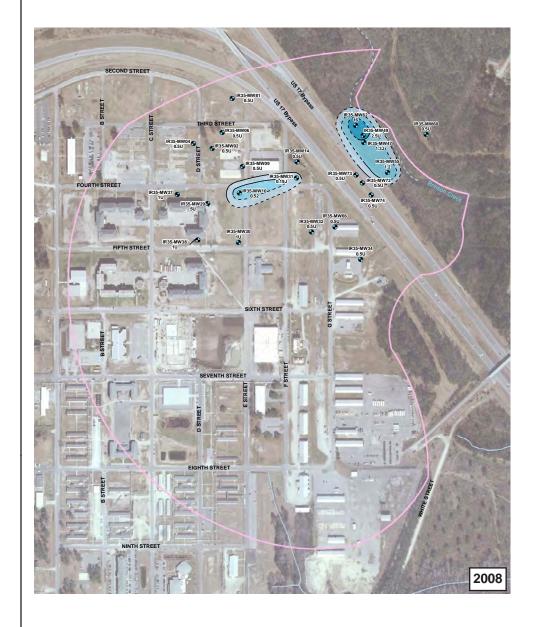
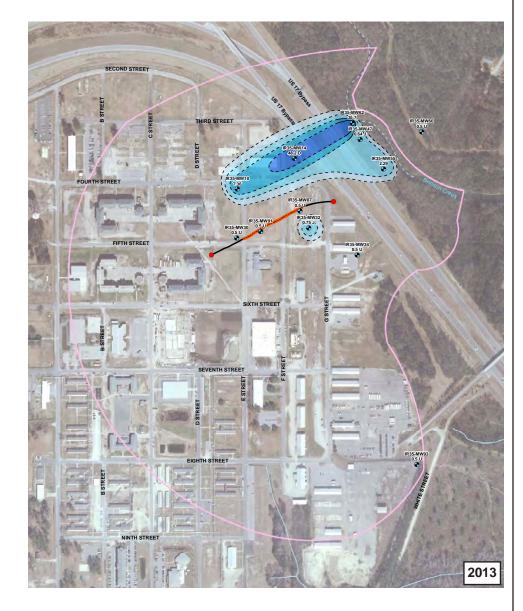


Figure 10-4 Site 35 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina









- Surficial Aquifer Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval

VC Extent (dashed where inferred)

0.03 μg/L - 0.3 μg/L

0.3 μg/L - 3 μg/L

3 μg/L - 30 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Notes:

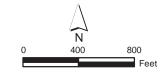
VC - Vinyl Chloride

VC NCGWQS - 0.03 μg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

U - analyte not detected above detection limit

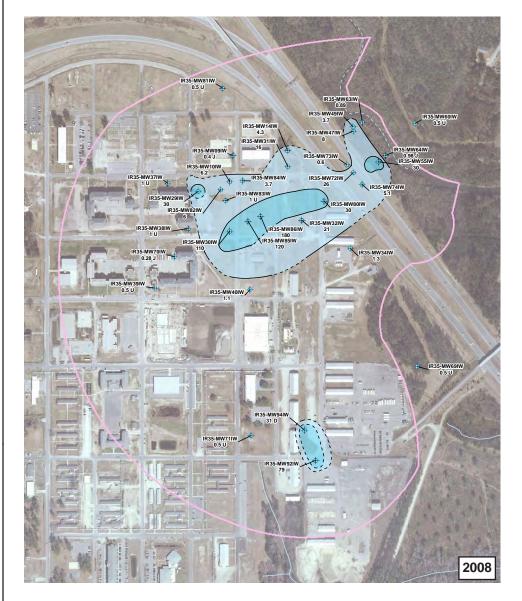
J - concentration is estimated



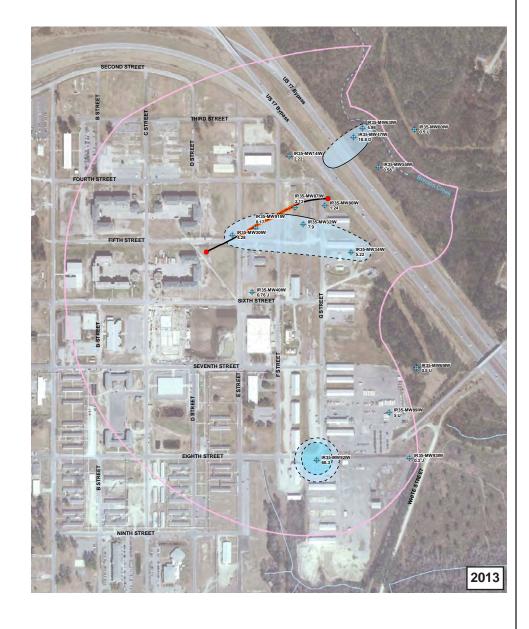
The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 10-5 Site 35 Approximate Extent of VC
Exceedances in the Surficial Aquifer
2015 Five-Year Review
Camp Lejeune North Carolina









- Surficial Aquifer Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval

TCE Extent (dashed where inferred)

3 μg/L - 30 μg/L

30 μg/L - 300 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Notes:

TCE - Trichloroethene

TCE NCGWQS - 3 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

- U analyte not detected above detection limit
- J concentration is estimated
- D Compound identified in an analysis at a secondary dilution factor

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

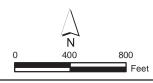
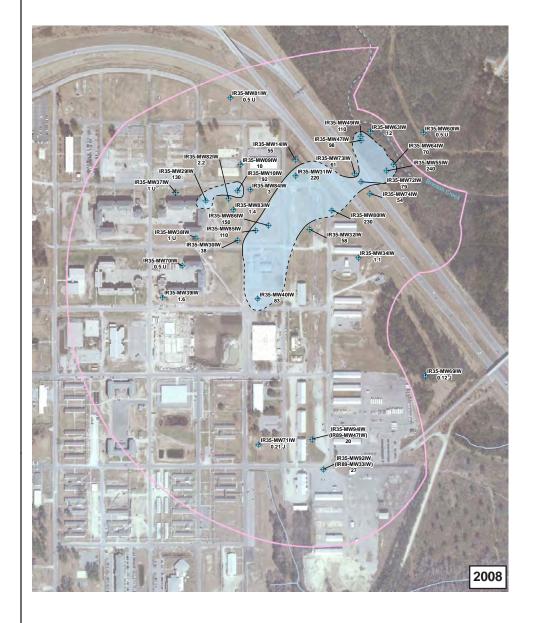
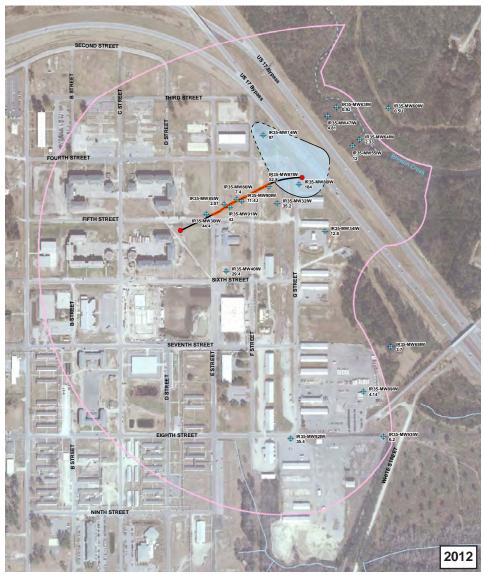
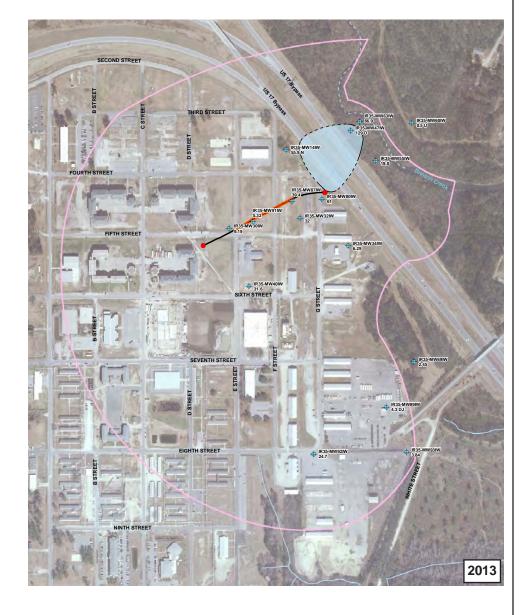


Figure 10-6 Site 35 Approximate Extent of TCE Exceedances in the UCH Aquifer 2015 Five-Year Review Camp Lejeune North Carolina









- Surficial Aquifer Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval cis-1,2-DCE Extent (dashed where inferred)

70 μg/L - 700 μg/L

Land Use Control Boundaries Aquifer Use Control Boundary

DCE - Dichloroethene

cis-1,2-DCE NCGWQS - 70 μ g/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

Notes:

U - analyte not detected above detection limit

J - concentration is estimated

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

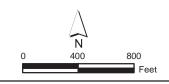
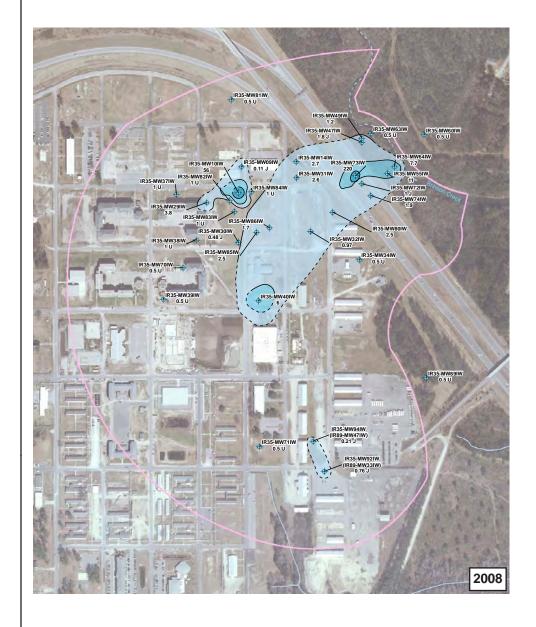
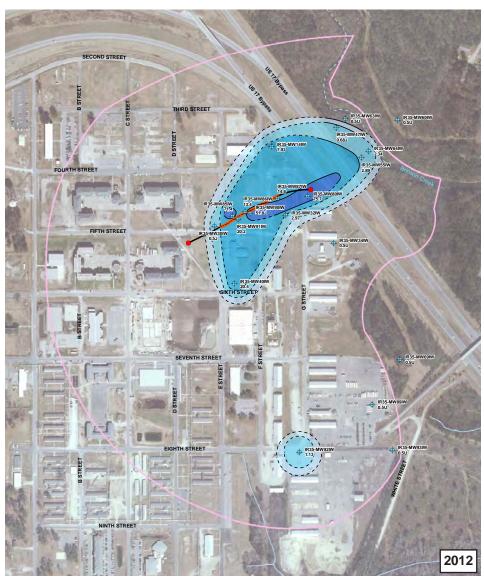
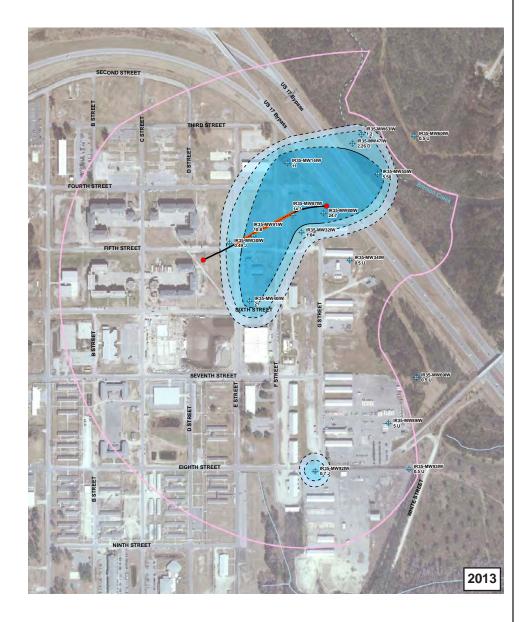


Figure 10-7 Site 35 Approximate Extent of cis-1,2-DCE Exceedances in the UCH Aquifer 2015 Five-Year Review Camp Lejeune North Carolina









- Surficial Aquifer
- Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval

VC Extent (dashed where inferred) 0.03 µg/L - 0.3 µg/L

- 0.3 μg/L 3 μg/L 3 μg/L - 30 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Notes:

VC - Vinyl Chloride

VC NCGWQS - 0.03 μg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

- U analyte not detected above detection limit
- J concentration is estimated

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

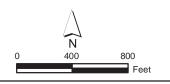
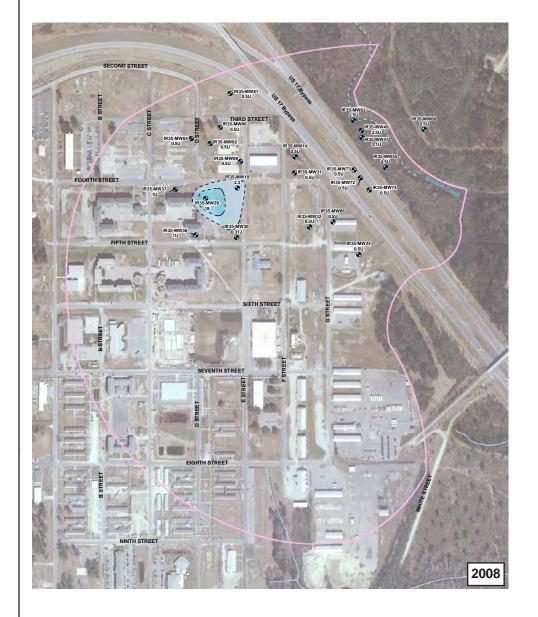
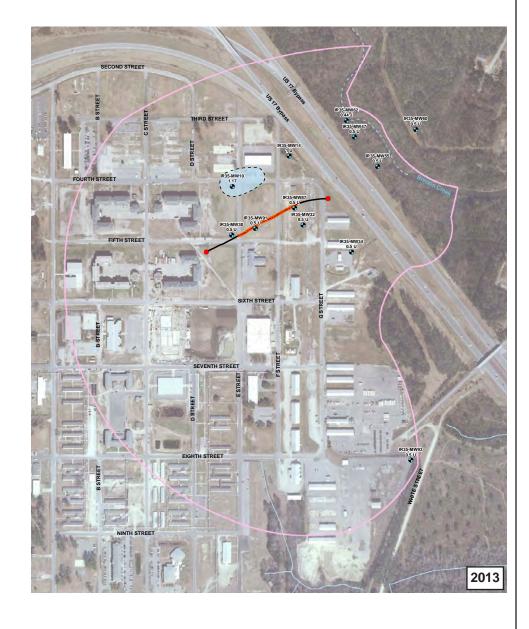


Figure 10-8 Site 35 Approximate Extent of VC
Exceedances in the UCH Aquifer
2015 Five-Year Review
Camp Lejeune North Carolina









- Surficial Aquifer Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval

Benzene Extent (dashed where inferred)

1 μg/L - 10 μg/L 10 μg/L - 100 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Benzene NCGWQS - 1 µg/L (April 2014) NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

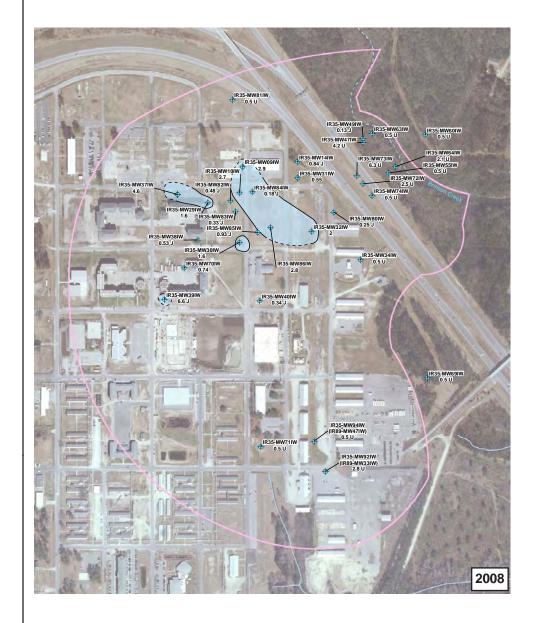
U - analyte not detected above detection limit

J - concentration is estimated

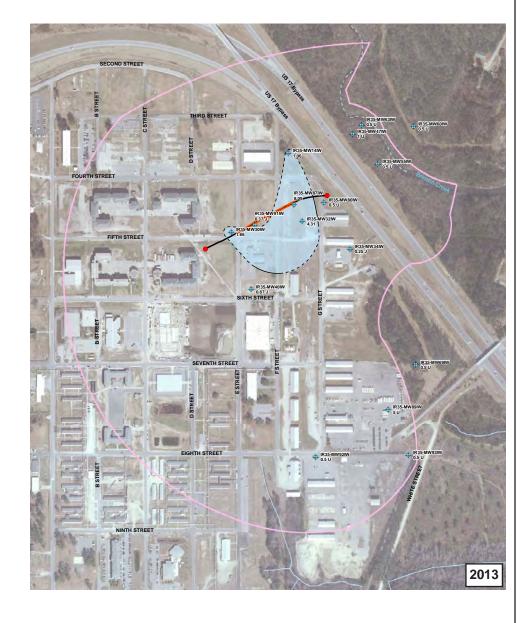
The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 10-9 Site 35 Approximate Extent of Benzene
Exceedances in the Surficial Aquifer
2015 Five-Year Review
Camp Lejeune North Carolina









- Surface Water Centerline
- HDD Well Entry/Exit PointHorizontal Well and Screened Interval
- Benzene Extent (dashed where inferred) Surficial Aquifer 1 μg/L - 10 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Notes:

Benzene NCGWQS - 1 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2013 plumes are based on the current LTM network at the time of each respective sampling event.

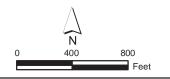


Figure 10-10 Site 35 Approximate Extent of Benzene
Exceedances in the UCH Aquifer
2015 Five-Year Review Camp Lejeune North Carolina



Operable Unit 11 (Sites 7 and 80)

11.1 Site History and Background

OU 11 is within the northeast portion of the Base, adjacent to the Northeast Creek (**Figure 1-2**). OU 11 consists of two sites (Sites 7 and 80) that have been grouped together because of their similar disposal history and proximity to one another. Site 7 was closed with NFA in 1997 and will not be discussed further.

Site 80 — Paradise Point Golf Course Maintenance Area is approximately 3 acres within the Paradise Point Golf Course (Figure 11-1). Information regarding past maintenance procedures at Site 80 is unknown; however, the facility is currently in operation. Golf course maintenance operations, which include the machine shop (a potential source of waste oils), a wash pad, and the routine spraying of pesticides and herbicides, may have contributed to potential contamination at this site. It is unknown when the wash pad was constructed, and what the procedure was for cleaning maintenance equipment prior to the construction of the wash pad.

1991	•SI (Site 7 & 80)
1994- 1996	•RI (Site 7 & 80)
1996	•TCRA (Soil - Site 80)
1996- 1997	•PRAP/ROD (Site 7 & 80)
1997	•NFA (Site 7)
2007- Present	•RIP (LUCs - Site 80)
2012	•ESD for LUCs (Site 80)

11.2 Site Characterization

The findings from various investigations at OU 11 that are pertinent to the FYR are summarized in this section.

11.2.1 Physical Characteristics

- Surface Features Site 80 is relatively flat, with a slight slope to the northeast, and is partially wooded. A machine shop, a maintenance building (Building 600), and a maintenance wash down area are present at Site 80. A drainage ditch is east of the wash down area.
- Geology and Hydrogeology Subsurface conditions at Site 80 primarily consist of silty sand, sand, and silty clay (Baker 1996). Fill material was identified in the lawn area. Primary groundwater flow direction is northnorthwest towards Northeast Creek.

11.2.2 Land Use

- Current Land Use Site 80 operates as the maintenance facility for Paradise Point Golf Course.
- Future Land Use There are no anticipated changes in land use.

11.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 11 RI report (Baker, 1996) and the ROD (Baker, 1997).

- Pesticides were detected in surface and subsurface soil in the west-northwest portion of the site at
 concentrations above screening levels. Metals were also detected in soil at concentrations above background
 levels. Low levels of pesticides, SVOCs, and metals were detected in groundwater but did not exceed
 screening levels or, in the case of metals, were within range of background concentrations.
- A HHRA and ERA were completed for Site 80 as part of the 1996 RI (Baker, 1996). Potential unacceptable risks were identified for current Base personnel and future residents from pesticides and metals in soil. Potential unacceptable risks were identified for future residents if exposed to arsenic in the groundwater. The human health risks were considered to be minimal since arsenic was only detected in one monitoring well at a concentration above the then current state and federal drinking water standard of 50 μg/L, the well was

ES120414012346RAL 11-1

observed to have poor groundwater recharge, samples collected from the well were silty, and the TSS were relatively high, which may have contributed to the elevated arsenic detection.

11.2.4 Interim Removal Actions

Prior to submitting the ROD, a TCRA was completed from March to August 1996 to remove approximately 988 tons of pesticide-contaminated soil. Soils were excavated for offsite disposal. Pesticide concentrations in soil confirmation samples collected from each excavation site did not exceed the cleanup levels that were based on industrial worker risk-based concentration (OHM, 1996).

11.3 Remedial Action Objectives

The ROD addressing soil and groundwater at OU 11 was signed on August 21, 1997 (Baker, 1997) and the selected remedy was "no action". Although the ROD did not require RA, the soil remediation goals for the TCRA were based on industrial RBCs; to protect human health and the environment, the Base implemented LUCs in May 2007 to prohibit future exposure to surface and subsurface soil within the site boundary, including the previous soil removal action area.

An ESD was submitted in 2012 to document the LUCs as the remedy (CH2M HILL, 2012). The RAO identified for Site 80 is prevent exposure to pesticides in soil. The cleanup levels used in the TCRA are presented in **Table 11-1**.

11.4 Remedial Actions

The OU 11 RA components and expected outcomes are summarized in Table 11-2. The RA for OU 11 includes:

- LUC implementation to prevent potential exposure to COCs in surface and subsurface soil as follows:
 - Prohibit the development and use of property for residential housing, elementary and secondary schools, day care facilities, and recreational areas within the site boundary.
 - Restrict intrusive activities within the site boundary.

11.4.1 Remedy Implementation

LUCs were implemented at Site 80 in 2007 (CH2M HILL, 2007). The LUCs were recorded with Onslow County as a Notice of a Contaminated Site and are included in the Base GIS and Master Planning.

11.4.2 Remedy Operation and Maintenance

LUCs are shown on Figure 11-1 and summarized in Table 11-3.

TABLE 11-3
OU 11 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date	
Non-Industrial Use Control Boundary (Soil)	3.2	May 2007	Fobruary 2007	
Intrusive Activities Control Boundary (Soil)	3.2	IVIAY 2007	February 2007	

Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate the LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed.

11.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 11-4.

11-2 ES120414012346RAL

TABLE 11-4
2010 FYR OU 11 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Dated Completed/Current Status
NFA was the selected remedy in the ROD	Submit an ESD to identify LUCs as the remedy. (2012)	Completed in 2012. An ESD was submitted in 2012 to document the LUCs as the remedy at Site 80 (CH2M HILL, 2012).
Monitoring wells remain in place	Abandon existing monitoring wells in accordance with NC Regulations. (2012)	Completed in 2011. A visual inspection of the site confirmed that no monitoring wells were present at Site 80.

11.5 Technical Assessment

Is the remedy functioning as designed?

Yes. The TCRA removed potential unacceptable risks to current and reasonably anticipated future receptors and LUCs have been implemented to prohibit non-industrial land use and restrict intrusive activities.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The cleanup levels for pesticides in soil were identified as the USEPA Region III RBCs for industrial soil in the TCRA. The 2014 RSLs have changed for aldrin and dieldrin (lower) and 4,4-DDD and 4,4-DDT (higher) (**Table 11-1**). The confirmation soil sample results documenting the removal of the pesticide-contaminated soil indicate that the cleanup levels identified in the ROD were met (OHM, 1996). However, the maximum concentration of dieldrin from confirmation samples exceeds the updated RSL (**Table 11-1**). A risk screening was completed using the maximum concentrations from the TCRA and the risks were within the acceptable risk management range for industrial workers (**Table 11-5**).

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

11.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 11 during this review.

11.7 Statement of Protectiveness

The remedy at OU 11 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through LUCs. LUCs are in place to restrict soil intrusive activities and prohibit non-industrial use within the extent of the former soil removal action areas where pesticides remain in soil above levels that allow for UU/UE.

11.8 References

Baker. 1996. Remedial Investigation Report Operable Unit No. 11 (Site 80). Marine Corps Base Camp Lejeune, North Carolina. April.

Baker. 1997. Record of Decision Operable Unit No. 11 (Sites 7 and 80). Marine Corps Base Camp Lejeune, North Carolina. April.

CH2M HILL. 2007. Land Use Control Implementation Plan, Operable Unit Number 11, Site 80. Marine Corps Base Camp Lejeune, North Carolina. May.

CH2M HILL. 2012. Explanation of Significant Different Operable Units 8 (Site 16), 11 (Site 80), and 13 (Site 63). Marine Corps Installations East – Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. July.

OHM. 1996. Contractor's Closeout Report Time Critical Removal Action for Pesticide Contaminated Soil Operable Unit No. 11, Site 80. Marine Corps Base Camp Lejeune, North Carolina.

ES120414012346RAL 11-3

TABLE 11-1
Cleanup Levels for OU 11 (Site 80)

Camp Lejeune, North Carolina

2015 Five-Year Review

Media	COCs	TCRA Cleanup Levels (Baker, 1996)	2014 Adjusted ¹ Industrial Soil RSL	2014 Adjusted ¹ Residential Soil RSL	Maximum Concentration ²
	Pesticides				
	Aldrin	340	140	31	Not detected
	Alpha-Chlordane	4,400	8,000	1,800	220
Soil (µg/kg)	Dieldrin	360	140	33	260
	4,4-DDD	2,400	9,600	2,200	1,300
	4,4-DDT	1,700	8,600	1,900	610
	Gamma-Chlordane	4,400	8,000	1,800	230

Notes:

Shading indicates cleanup levels achieved

¹RSLs are adjusted for non-carcinogens by dividing the RSL by 10 to account for cumulative effects from exposure to multiple chemicals

²Contractor's Closeout Report, TCRA Soil Remediation (OHM, 1996)

TABLE 11-2

OU 11 Remedial Action Summary and Expected Outcomes

2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
80	Soil	Potential risk to future residents from exposure to pesticides in soil.		Prevent exposure to pesticides in soil.	LUCs	Maintain intrusive and non-industrial use controls and monitor quarterly.	Industrial/ Recreational Land Use

TABLE 11-5

OU 11 Surface and Subsurface Soil Screening, Industrial Scenario - Risk Ratio, Maximum Detected Concentration

2015 Five-Year Review

Camp Lejeune, North Carolina

Analyte	Maximum Detected Concentration (MG/KG)	Noncarcinogenic Industrial Soil RSL HQ=1 (MG/KG)	Carcinogenic Industrial Soil RSL Excess Lifetime Cancer Risk = 1.0E-6 (MG/KG)	Corresponding Hazard Index ^a	Corresponding Cancer Risk ^b	Target Organ
Aldrin	Not detected	2.5E+01	1.4E-01	Not detected	Not detected	Liver
Alpha-Chlordane	2.2E-01	5.0E+02	8.0E+00	0.0004	3E-08	Liver
Dieldrin	2.6E-01	4.1E+01	1.4E-01	0.006	2E-06	Liver
4,4-DDD	1.3E+00	N/A	9.6E+00		1E-07	
4,4-DDT	6.1E-01	5.2E+02	8.6E+00	0.001	7E-08	Liver
Gamma-Chlordane	2.3E-01	5.0E+02	8.0E+00	0.0005	3E-08	Liver
Cumulative Corresponding Hazard Index ^c				0.008		
Cumulative Corresponding Cancer Risk ^d					2E-06	
					Total Liver HI =	0.008

Notes:

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05, otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

mg/kg = milligrams per kilogram

N/A = Not available/not applicable

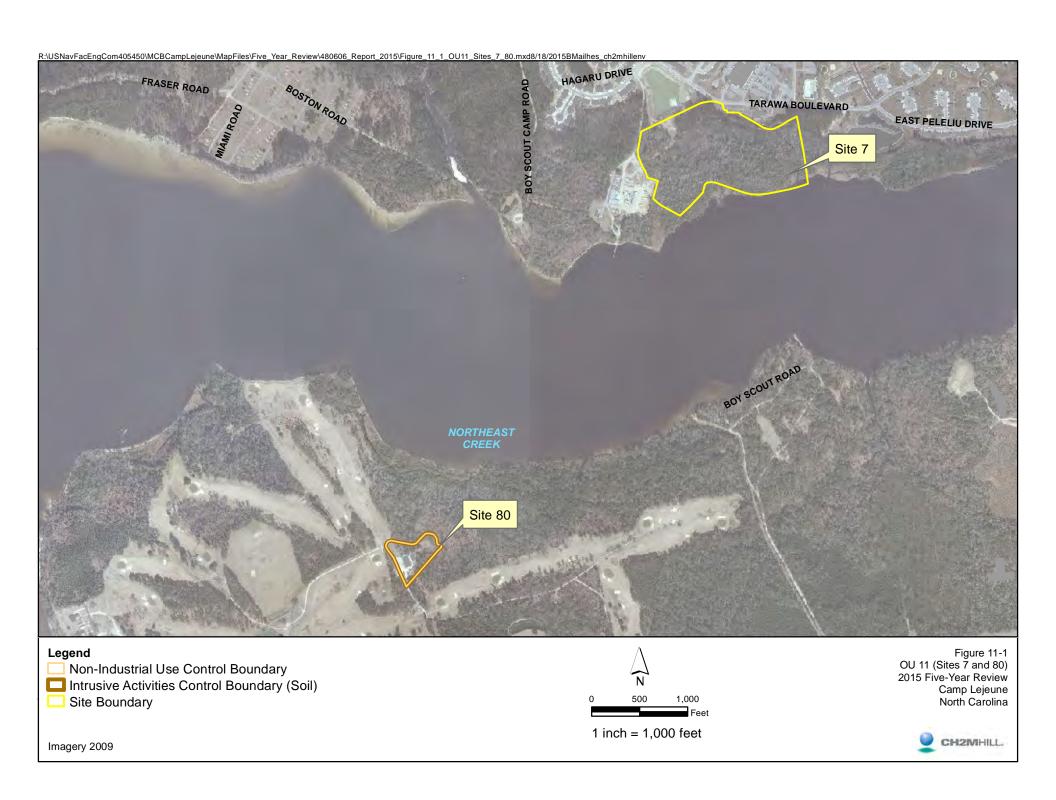
RSL = Residential Screening Level (November 2014)

^a Corresponding Hazard Index equals maximum detected concentration divided by the noncarcinogenic RSL divided by the acceptable hazard level of 1

^b Corresponding Cancer Risk equals maximum detected concentration divided by the carcinogenic RSL divided by the acceptable risk level of 1 x 1C⁶.

^c Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.

^d Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent.



Operable Unit 12 (Site 3)

12.1 Site History and Background

OU 12 is within the Mainside area of the Base (Figure 1-2) and consists of Site 3.

Site 3 — the Old Creosote Plant is approximately 5 acres (Figure 12-1). The site reportedly operated from 1951 to 1952 to supply treated lumber during construction of the Base Railroad. An onsite sawmill, which supplied cut timbers for the creosote treatment, was reportedly located in the northern portion of the site (Figure 12-2).

12.2 Site Characterization

The findings from various investigations at OU 12 that are pertinent to the FYR are summarized in this section.

1983	•IAS	
1991	•Site Investigation	
1994- 1996	•RI/FS	
1997	•PRAP/ROD	
1997- Present	•RIP (LTM and LUCs)	
2000	•NTCRA: Soil removal, Amended ROD	
2001	•LUCs Implemented	
2002	•LUCs Updated	

12.2.1 Physical Characteristics

- Surface Features OU 12 is relatively flat, unpaved, and covered with unmaintained grass. The site is bordered on the north, east, and south sides by woods. A gravel road bisects the site from west to east and the Camp Lejeune Railroad line runs parallel to the site's western edge and intersects an old railroad spur line at the site's southern boundary. Remnants of the former creosote plant, including a chimney, concrete pads, and train rails, can be found on the surface of the site. Stormwater runoff flows toward drainage swales located along the eastern and western boundaries of the site, ultimately discharging to Wallace Creek to the south.
- Geology and Hydrogeology Site 3 is primarily underlain by sand and silty sand with occasional discontinuous layers of silt and clay. Groundwater is typically encountered at depths ranging from approximately 4 to 21 feet bgs and flows to the southwest, towards an unnamed tributary of Wallace Creek. The surficial aquifer in the area of Site 3 extends to a depth of approximately 30 feet bgs. Localized areas of perched groundwater appear to be present. The UCH aquifer extends from approximately 30 feet bgs to approximately 90 feet bgs, where the MCH aquifer is encountered. The MCH aquifer extends to approximately 140 feet bgs (Baker, 1996a).

12.2.2 Land Use

- Current Land Use Site 3 is currently vacant.
- **Future Land Use** There are no anticipated changes in land use.

12.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are provided in the OU 12 RI (Baker, 1996a) and the OU 12 ROD (Baker, 1997).

- VOCs and SVOCs (primarily PAHs) were detected in the soil and groundwater, and fuel constituents were detected in groundwater at concentrations above screening levels during previous site investigations.
- An HHRA and ERA were completed for Site 3 during the 1996 RI. Potential unacceptable risks were identified
 for future residents from SVOCs (primarily PAHs) and VOCs in groundwater if used as a potable water supply.
 There were no unacceptable ecological risks identified.

ES120414012346RAL 12-1

12.3 Remedial Action Objectives

The ROD addressing soil and groundwater at OU 12 was signed on April 3, 1997 and included the following RAOs (Baker, 1997):

- Prevent leaching of PAH contaminants from subsurface soil to groundwater.
- Remediate subsurface soil and shallow groundwater.
- Prevent exposure to PAH contaminated groundwater.

The cleanup levels for OU 12 groundwater and soil are presented in Tables 12-1 and 12-2, respectively.

12.4 Remedial Actions

The OU 12 RA components and expected outcomes are summarized in **Table 12-3**. The RA for OU 12 includes the following major components:

- Source removal with onsite biological treatment of soil with PAH concentrations above the NC soil screening levels (SSL).
- LTM to monitor changes in VOC and SVOC concentrations and extent in groundwater.
- LUC implementation for soil and groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring, from the aquifers (surficial and Castle Hayne) within 1,000 feet of the estimated impacted groundwater extent.
 - Prohibit non-industrial land use within the extent of the former soil removal which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.
 - Restrict intrusive activities within the vicinity of the estimated impacted groundwater and soil extents.

12.4.1 Remedy Implementation

Source Removal

A pilot-scale treatability study was conducted in 1998 and results indicated that biological treatment of the soil was not effective. As a result, an Amended ROD was signed in 2000 and included excavation of soil with offsite disposal. An NTCRA to remove PAH-contaminated soil above NC SSLs was completed in 2000. Approximately 3,300 tons of PAH-contaminated soil was removed to the depth of the water table and disposed of offsite (OHM, 2001).

Long-term Monitoring and Land Use Controls

LTM at Site 3 was initiated in 1997 and is ongoing as described in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002a). The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

12.4.2 Remedy Operation and Maintenance

Long-term Monitoring

LTM at Site 3 initially consisted of collecting groundwater samples from three surficial and one UCH aquifer monitoring wells for VOCs and SVOCs annually. LTM currently includes the same monitoring well network but samples are analyzed biennially for SVOCs. Sampling locations are shown on **Figure 12-1**. A pilot study using passive treatment to stimulate aerobic degradation of COCs is planned to enhance biodegradation of the COCs and accelerate progress toward site closeout (CH2M HILL, 2013).

The last sampling event took place in FY 2013 and the next sampling event will take place in FY 2015. Beginning in FY 2015, all VOC COCs and nine SVOCs were removed from LTM because concentrations during the previous four consecutive LTM events did not exceed the cleanup goals (**Table 12-1**, CH2M HILL, 2013).

12-2 ES120414012346RAL

The annual cost of LTM at OU 12 is approximately \$10,000.

Land Use Controls

Currently, signage and a wire fence restrict access to the site. The LUCs are shown on **Figure 12-1** and summarized in **Table 12-4**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

TABLE 12-4
OU 12 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Non-Industrial Use Control Boundary (Soil)	0.14		
Intrusive Activities Control Boundary (Groundwater)	4.1	July 2002	February 2002
Aquifer Use Control Boundary (1,000 feet)	134.1		

12.4.3 Progress since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in **Table 12-5**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 12-2**.

TABLE 12-5 2010 FYR OU 12 Recommendations/Follow-up Actions

Issues Recommendations (Milestones)		Date Complete/Current Status	
Cleanup levels have changed since the ROD	Update groundwater COCs and cleanup levels to reflect recent standards (2012).	Completed in 2011. Completed periodically as part the LTM program. Cleanup levels have been update to reflect current NCGWQS.	
Potential for VI pathway	Evaluate and mitigate VI pathway during construction planning (ongoing).	Ongoing. There is no unacceptable risk from VI based on current land use and VOCs were not detected in groundwater at concentrations above the cleanup levels during the last four sampling events (CH2M HILL, 2013).	

12.5 Technical Assessment

Is the remedy functioning as designed?

Yes, the OU 12 remedy is functioning as designed. The TCRA removed the impacted soil that was the source of PAH contamination to groundwater, LTM is ongoing, and LUCs are in place to prevent exposure to COCs at concentrations above cleanup levels.

Long-term Monitoring

Post-soil removal groundwater data from IR03-MW02 show decreases in COCs over time (**Figure 12-3**). However, benzo(a)anthracene has exceeded cleanup levels for several rounds of LTM and concentrations appear to be stable (**Figure 12-4**). The remaining COCs (**Table 12-1**) have been detected sporadically at concentrations above screening levels during the last several rounds of LTM. These COCs degrade aerobically and DO in the impacted monitoring wells has consistently been below 1 mg/L, indicating unfavorable conditions for degradation. A pilot study is being conducted to promote aerobic biodegradation of the remaining COCs in the surficial and UCH

ES120414012346RAL 12-3

aquifers in the former soil removal area. Performance monitoring of the pilot study will be conducted on a quarterly basis for 9 months post implementation.

Land Use Controls

LUCs remain in place to prohibit non-industrial land use, restrict intrusive activities below the water table, and prohibit aquifer use. Soil LUCs were put in place to prevent activities that may enhance possible migration of contaminants. Once the groundwater concentrations are below cleanup levels, all LUCs may be removed and the site will be recommended for closure.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The groundwater cleanup levels were identified as the more conservative of the Federal MCLs or NCGWQS at the time the ROD was signed. Since that time, the groundwater standards have been updated as listed in **Table 12-1**. Groundwater COCs will remain in the LTM program until they are detected at or below cleanup levels for four consecutive events at which point LUCs will be removed.

The cleanup levels for SVOCs in soil were identified as the NC SSLs. The recent (February 2012) NC SSLs for benzo(a)anthracene, 2-methylnaphthalene, and naphthalene are more conservative than the levels during the ROD (**Table 12-2**). However, there were no unacceptable risks from exposure to soil and the soil removal action was implemented to remove a potential source to groundwater. As a result, concentrations in groundwater have decreased since the soil removal action. Therefore changes in the NC SSL do not affect protectiveness and soil LUCs can be removed once groundwater COCs are below cleanup levels.

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 12.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs and chemicals detected at the site (**Table 2-1**), LTM is ongoing to monitor COCs in groundwater and the LUCs prevent exposure to groundwater until cleanup levels are achieved. Thus, toxicity changes would not affect the protectiveness of the remedy.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

12.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 12 during this review.

12.7 Statement of Protectiveness

The remedy at OU 12 protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled. LTM is ongoing to monitor the SVOC concentrations and LUCs are in place to restrict intrusive activities, non-industrial land use, and aquifer use until groundwater cleanup levels are achieved.

12.8 References

Baker. 1996a. Remedial Investigation Report, Operable Unit No. 12 (Site 3). Marine Corps Base, Camp Lejeune, North Carolina. July.

Baker. 1996b. Feasibility Study for Operable Unit No. 12 (Site 3). Marine Corps Base, Camp Lejeune, North Carolina. August.

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12-4 ES120414012346RAL

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OHM. 2000. Remediation Action Contractor's Closeout Report, Operable Unit No. 12, Site 3. Marine Corps Base Camp Lejeune. North Carolina. October.

ES120414012346RAL 12-5

TABLE 12-1
Groundwater Cleanup Levels for OU 12 (Site 3)
2015 Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Level	Current Cleanup Level		
iviedia	Cocs	(Baker, 1997)	Concentration	Reference	
	VOCs				
	Benzene	1	1	NCGWQS	
	Chloroform	0.19	70	NCGWQS	
	Vinyl chloride		0.03	NCGWQS	
	SVOCs				
	Acenaphthene		80	NCGWQS	
	Benzo(a)anthracene	0.05	0.05	NCGWQS	
	Benzo(a)pyrene	2	0.005	NCGWQS	
	Benzo(b)flouranthene	0.12	0.05	NCGWQS	
	Benzo(k)flouranthene	1	0.5	NCGWQS	
	Bis(2-ethylheyxl)phthalate		3	NCGWQS	
Groundwater (μg/L)	Carbazole	4	2	NCGWQS	
	Chrysene	5	5	NCGWQS	
	Dibenzofuran	6	28	NCGWQS	
	2,4-Dimethylphenol	31	100	NCGWQS	
	2-Methylnaphthalene	63	30	NCGWQS	
	2-Methylphenol	78	93	RSL-Tapwater	
	Naphthalene	21	6	NCGWQS	
	Phenanthrene	210	200	NCGWQS	
	Phenol	300	30	NCGWQS	
	Metals				
	Aluminum	50	2,000	RSL-Tapwater	
	Iron	300	300	NCGWQS	

Notes:

--- COC identified post-ROD based on exceedances of current cleanup levels during LTM Shading indicates cleanup levels achieved per LTM Report (CH2M HILL, 2014)

Cleanup Level Reference Dates:

MCL (May 2009)

NCGWQS (April 2013)

RSL (November 2014)

TABLE 12-2
Soil Cleanup Levels for OU 12 (Site 3)
2015 Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels (Baker, 1997)	2014 NC SSL	Maximum Concentration ¹	
	SVOCs				
Soil (µg/kg)	Benzo(a)anthracene	343	180	180	
	Carbazole	273	370	Not Detected	
	Chrysene	3,810	18,000	410	
	2-Methylnaphthalene	4,900	1,600	Not Detected	
	Naphthalene	585	210	88	

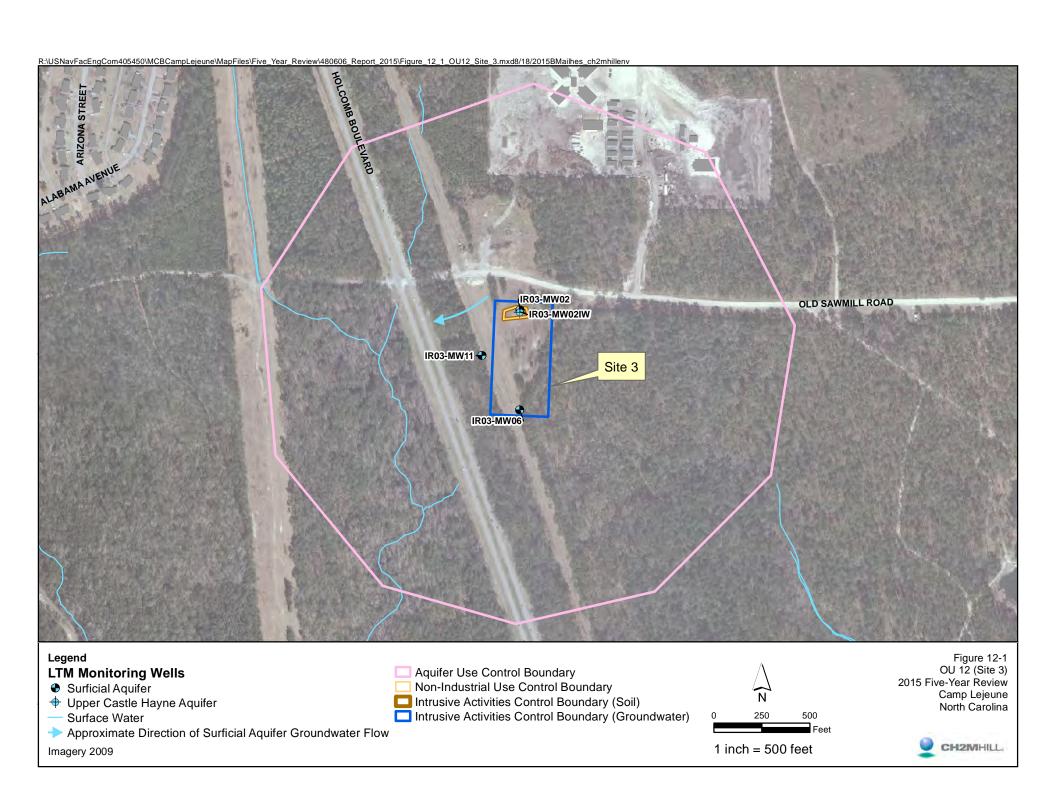
Notes:

Shading indicates cleanup levels achieved

¹Maximum concentration: Remedial Action Contractor's Closeout Report (OHM, 2000)

TABLE 12-3
OU 12 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
		PAHs in soil are a potential source of groundwater contamination.	Vacant/Industrial	Remediate subsurface soil.	Soil Removal	Excavation and offsite disposal of soil to the NC SSL to remove potential source of PAHs to groundwater.	
	Soil			Prevent leaching of PAH contaminants from subsurface soil to groundwater. Remediate subsurface soil.	LUCs	Maintain non-industrial use control and monitor quarterly until groundwater cleanup levels are achieved.	111/15
3	Groundwater	Potential unacceptable risks to future residents from		Remediate shallow groundwater.	LTM	Implement groundwater LTM to monitor COC concentrations until each groundwater COC is at or below its respective cleanup level for 4 consecutive sampling events.	UU/UE
	svocs in groundwater.		Prevent exposure to PAH- contaminated groundwater.	LUCs	Maintain instrusive activities and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.		



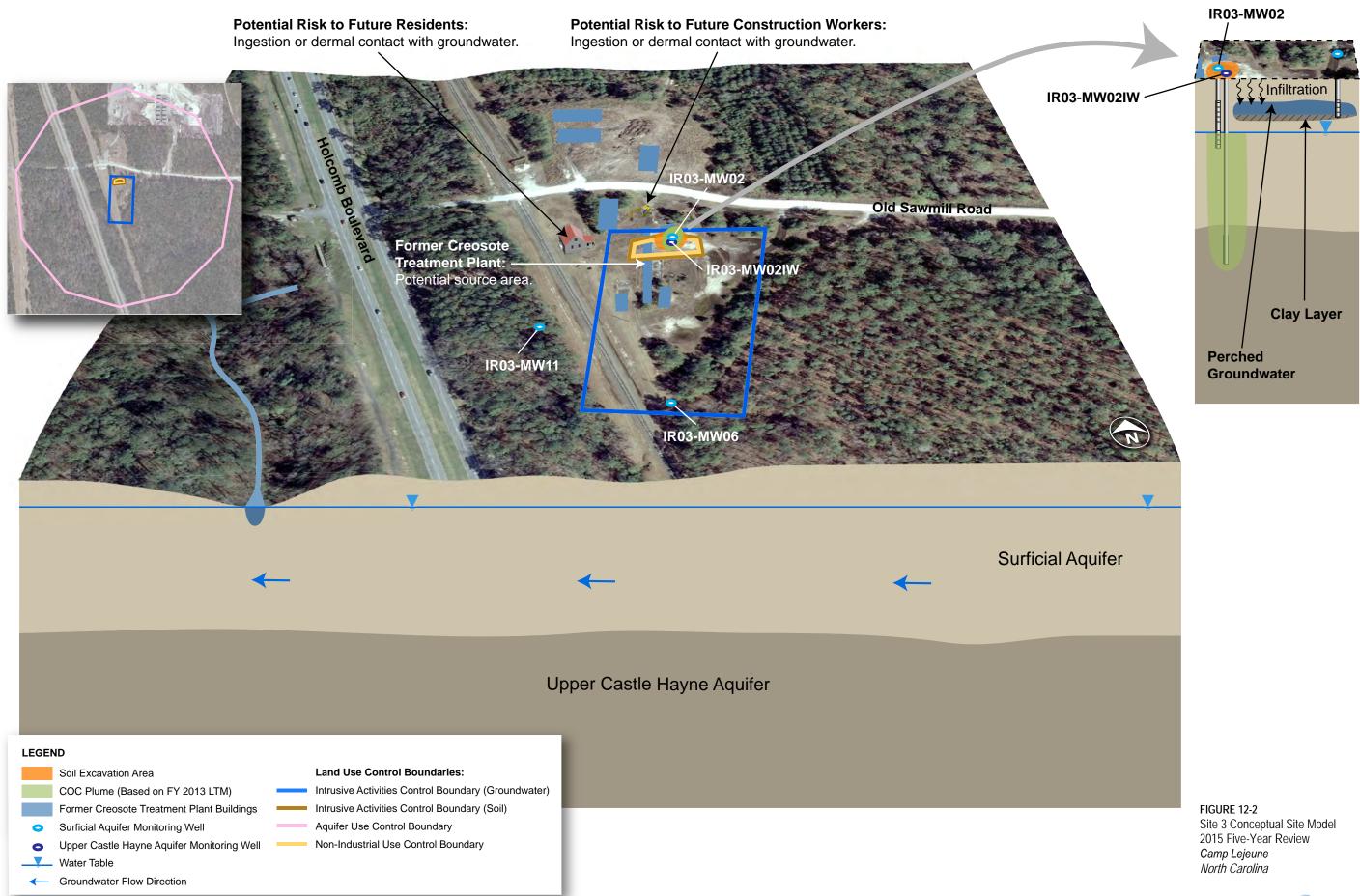


Figure 12-3 COC Trends IR03-MW02 2015 Five-Year Review Camp Lejeune, North Carolina

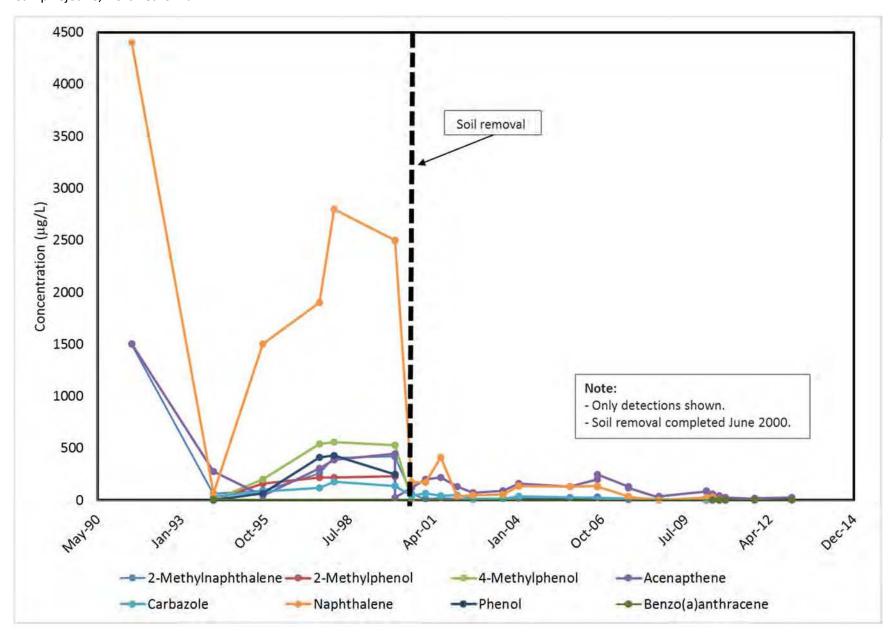
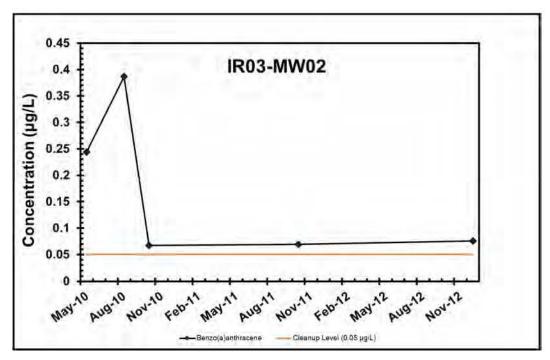
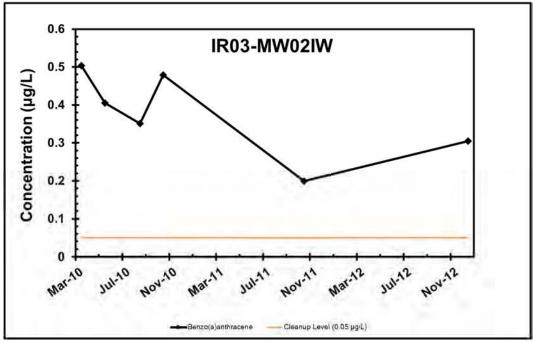


Figure 12-4
Benzo(a)anthracene Trends
2015 Five-Year Review
Camp Lejeune, North Carolina





Notes:

Only detections shown

Benzo(a)anthracene was detected in a sample collected from IR03-MW02 in February 1994 and not detected above laboratory reporting limits again until May 2010. It was not detected in samples collected from IR03-MW02IW until March 2010.

Operable Unit 13 (Site 63)

13.1 Site History and Background

OU 13 is south of the MCAS New River (Figure 1-2) and consists of Site 63.

Site 63 — **Verona Loop Dump** is approximately 5 acres, nearly 2 miles south of the MCAS New River operations area (**Figure 13-1**). The area reportedly received bivouac wastes generated during training exercises. No hazardous wastes were reportedly disposed of at Site 63.

13.2 Site Characterization

The findings from various investigations at OU 13 that are pertinent to the FYR are summarized in this section.

1983	•IAS
1991	•Site Investigation
1996	•RI
1997	•PRAP/ROD
2001- 2002	•RIP (LUCs)
2012	•ESD
2013	•LUCIP

13.2.1 Physical Characteristics

- Surface Features Site 63 is relatively flat and heavily vegetated. The eastern portion of the site slopes
 towards an unnamed tributary that discharges into Mill Run approximately 2,000 feet south of the site. A
 drainage ditch along Verona Road receives surface water runoff from the extreme southern portion of the site
 and the asphalt road surface.
- **Geology and Hydrogeology** Subsurface conditions at the site generally consist of Coastal Plain deposits comprising layers of sand, silt, and clay. Site 63 appears to be located on a groundwater divide with flow to the west and to the east (Baker, 1996).

13.2.2 Land Use

- Current Land Use Site 63 is currently used for training exercises, maneuvers, and recreational hunting.
- Future Land Use There are no anticipated changes in land use.

13.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the OU 13 RI report (Baker 1996) and the OU 13 ROD (Baker, 1997).

- VOCs, SVOCs, pesticides, and metals were detected in soil, metals were detected in groundwater and surface water, and pesticides were detected in sediment.
- An HHRA and ERA were completed for Site 63 as part of the RI. No unacceptable human health or ecological
 risks were identified from exposure to site media; however, waste remains in place and could present an
 unacceptable risk to human health if exposure occurs.

13.3 Remedial Action Objectives

The ROD addressing soil and groundwater at OU 13 was signed in 1997 (Baker, 1997). Although the ROD did not require RA, for conservativeness the Base implemented LUCs in 2001 and updated them in 2002. An ESD was submitted in 2012 to document the LUCs as the remedy including the addition of a non-industrial use control and an intrusive activities control boundary for soil to prevent exposure to waste in place. (CH2M HILL, 2012). The RAO identified in the 2012 ESD is to prevent exposure to waste.

ES120414012346RAL 13-1

13.4 Remedial Actions

The OU 13 RA components and expected outcomes are summarized in **Table 13-1**. The RA for OU 13 consists of the following component:

- LUC implementation for soil and groundwater that may be impacted by waste as follows:
 - Prohibit non-industrial land use within the site boundary, which includes restrictions on the construction
 of residential housing, hospitals, hotels, nursing homes, and day care facilities.
 - Restrict intrusive activities within the site boundaries.
 - Restrict intrusive activities below the shallow groundwater table.
 - Prohibit the withdrawal and any use of groundwater, except for environmental monitoring, from the aquifers (surficial and Castle Hayne) within 1,000 feet of the Site.

13.4.1 Remedy Implementation

LUCs were implemented in 2001 and updated in 2002 (Baker, 2002a) and 2014 (CH2M HILL, 2014). The LUCs were recorded with Onslow County as a Notice of a Contaminated Site and are included in the Base GIS and Master Planning.

13.4.2 Remedy Operation and Maintenance

LUCs were updated in 2014 at Site 63 to prevent potential unacceptable exposure to soil that may have been impacted by buried waste (CH2M HILL, 2014). The LUCs were updated to add the intrusive activities control boundary for soil within the same boundary as the non-industrial use control boundary for soil. The current LUCs are shown on **Figure 13-1** and summarized in **Table 13-2**.

TABLE 13-2 OU 13 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Intrusive Activities Control Boundary (Soil)	5	August 2014	August 2014
Non-Industrial Use Control Boundary (Soil)	5		
Intrusive Activities Control Boundary (Groundwater)	2	July 2002	February 2002
Aquifer Use Control Boundary (1,000 feet)	100		

Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

13.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 13-3.

TABLE 13-3 2010 FYR OU 13 Recommendations/Follow-up Actions

Issues	Recommendations (Milestones)	Date Complete/Current Status	
NFA was the selected remedy in the ROD	Submit an ESD to identify LUCs as the remedy. (2013)	Completed in 2012. An ESD was submitted in 2012 to document the LUCs as the remedy at Site (CH2M HILL, 2012).	
Current LUCs do not prevent soil intrusive activities or prohibit non-industrial use	Update LUCs to include restrictions for soil to prevent potential exposure to waste. (2012)	Completed in 2014. A LUCIP was submitted in 2013 after the ESD was approved, and finalized in August 2014 (CH2M HILL, 2014).	

13-2 ES120414012346RAL

TABLE 13-3	
2010 FYR OU 13 Recommendations/Follow-up Actions	s

Monitoring wells remain in place

Abandon existing monitoring wells in accordance with NC Regulations. (2012)

Completed in April 2011. A visual inspection of the site confirmed that no monitoring wells were present at Site 63.

13.5 Technical Assessment

Is the remedy functioning as designed?

Yes. LUCs are in place to prohibit non-industrial land use and restrict intrusive activities.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes, the exposure assumptions and toxicity data are still valid. No ecological or human health risks were identified for OU 13; therefore, RAOs remain valid.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

13.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 13 during this FYR.

13.7 Statement of Protectiveness

The remedy at OU 13 is protective of human health and the environment and exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to restrict soil and groundwater intrusive activities and aguifer use.

13.8 References

Baker. 1996. Remedial Investigation Report, Operable Unit No. 13 (Site 63). Marine Corps Base Camp Lejeune, North Carolina. October.

Baker. 1997. Record of Decision Operable Unit No. 13 (Site 63). Marine Corps Base Camp Lejeune, North Carolina. January.

CH2M HILL. 2012. Explanation of Significant Difference Operable Units 8 (Site 16), 11 (Site 80), and 13 (Site 63). Marine Corps Installations East – Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. September.

CH2M HILL. 2014. *Land Use Control Implementation Plan, Site 63, Operable Unit No. 13*. Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina. August.

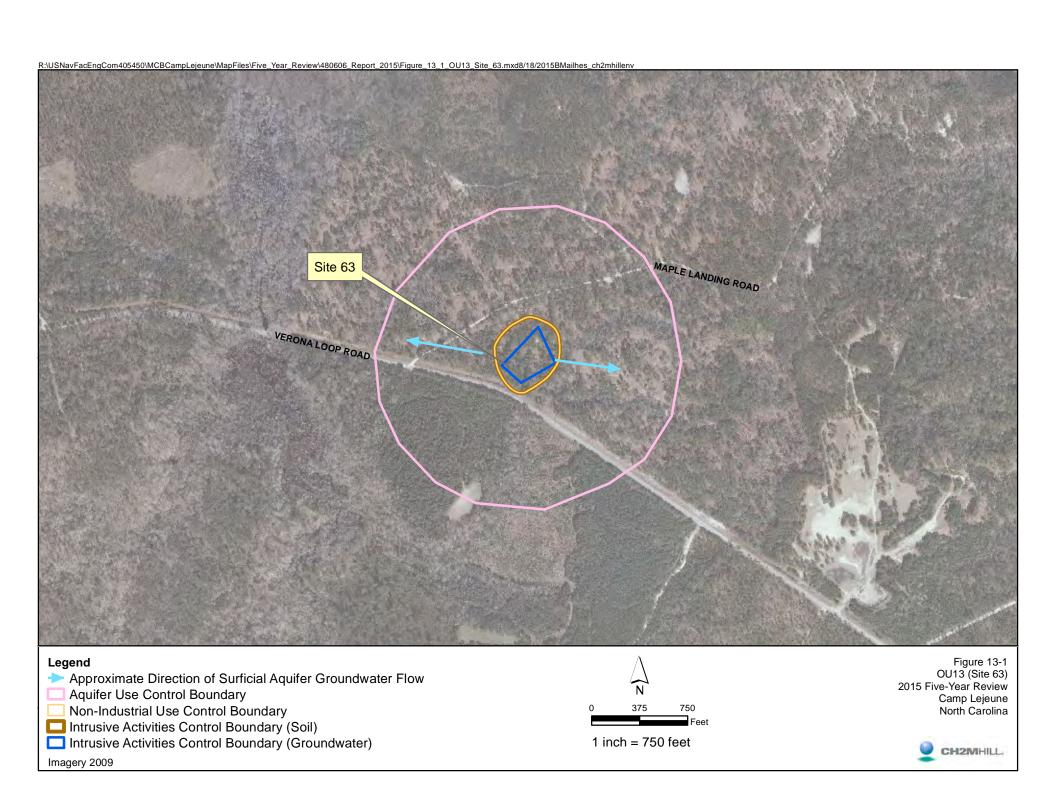
TABLE 13-1

OU 13 Remedial Action Summary and Expected Outcomes

2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/ Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
63		Potential unacceptable risks from exposure to site media based on site history as a waste disposal area.	Military	Prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.	LUCs	Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring. Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring.	Military Training/ Industrial



Operable Unit 14 (Site 69)

14.1 Site History and Background

OU 14 is within the Rifle Range operations area near Sneads Ferry (Figure 1-2) and consists of Site 69.

Site 69 — Rifle Range Chemical Dump is approximately 14 acres located west of the New River in the Rifle Range area (Figure 14-1). From 1950 to 1976, Site 69 was reportedly used to dispose of chemical wastes including PCBs, solvents, pesticides, and drums of gas that possibly contained cyanide (i.e., tear gas) or other training agents, also known as chemical agents. Site 69 is within a former explosive range, UXO-02, which was reportedly used from 1973 to 2002. UXO-02 was investigated under the MMRP and was granted NFA in July 2013 (CH2M HILL, 2013a).

14.2 Site Characterization

The findings from various investigations at OU 14 that are pertinent to the FYR are summarized in this section.

14.2.1 Physical Characteristics

- Surface Features OU 14 is on a west-east-trending ridge that gently slopes toward the east and the New River. The suspected disposal areas were covered with a multilayered cap in 2014. Outside of the cap area, the site is heavily wooded with primarily pine, dogwood, and oak trees. The perimeter of Site 69 is surrounded by a 6-foot-high chainlink fence with a locked access gate.
- Geology and Hydrogeology Subsurface
 conditions generally consist of Coastal Plain deposits consisting of mostly fine-grained, loose, poorly graded
 sand, with lesser amounts of silt and clay with depth. A semi-confining unit is present at the OU separating
 the surficial and UCH aquifers. Beneath the semi-confining unit the formation is composed of sands, silts,
 shell, and fossil fragments. Groundwater in the surficial aquifer flows radially outward from the center of
 Site 69, and groundwater in the UCH and MCH aquifers generally flows to the northeast (CH2M HILL, 2012c).

14.2.2 Land Use

ES120414012346RAL

- **Current Land Use** The site is currently vacant and undeveloped.
- Future Land Use There are no anticipated changes in land use.

14.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the Site 69 Supplemental Investigation report (CH2M HILL, 2011) and the OU 14 ROD (CH2M HILL, 2013b).

site of Supplemental investigation report (Chizivi filet, 2011) and the OO 14 NOD (Chizivi filet, 2013b).

-		
1980- 1981	•Radiation Survey and Soil Sampling	
1983	·IAS	
1984- 1987	•Confirmation Study	
1995- 1997	•RI	
1996- 1998	•In-Well Aeration Pilot Study	
1998	•PRAP	
2000	•IROD	
1998- 2005	•Interim RA (LTM and LUCs)	
2001	•LUCs Implemented	
2005	•Surface Water and Sediment Sampling	
2007	•Radiation Survey	
2008- 2011	•Supplemental Investigation	
2011- 2012	•UXO-02 Expanded Site Investigation	
2011- 2012	•FS	
2012- 2013	•PRAP & ROD (Capping, LTM, and LUCs)	
2013	•RD	
2014	•RIP (Cap)	
2015	•LTM and LUCs	

14-1

- Due to the potential for chemical agents at Site 69, soil samples were not collected within the suspected
 disposal area. Based on historical documentation and groundwater analytical data, the suspected disposal
 area likely contains buried drums of PCBs, chlorinated solvents, pesticides, and potentially contains drums of
 chemical agents. VOCs, pesticides, PCBs, and metals were detected in the groundwater at Site 69.
- An HHRA and ERA were completed for Site 69 as part of the Supplemental Investigation. Potential unacceptable risks were identified for future industrial workers and residents from exposure to CVOCs, pesticides, PCBs, and metals in surficial and UCH aquifer groundwater. Also, although unlikely, there is a potential risk to future industrial or residential receptors from exposure to CVOCs in indoor air if the VI pathway is completed by constructing buildings within 100 feet of the groundwater VOC plume. Unacceptable risks were assumed from exposure to waste and soil within the suspected disposal area. Ecological risks were assumed to be present as a result of waste left in place and the associated soil present in the disposal trenches and burial pits at Site 69 (CH2M HILL, 2011).

14.3 Remedial Action Objectives

An interim ROD was signed in June 2000 and included LUCs to mitigate human health risks from exposure to waste and impacted groundwater, and LTM to monitor plume stability (Baker, 2000). The interim ROD was superseded by the final ROD addressing soil, waste in place, and groundwater at OU 14, which was signed in June 2013 (CH2M HILL, 2013b). The RAOs for OU 14 are:

- Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Minimize exposure to potential chemical agent and chemical waste to the maximum extent practicable.
- Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable.
- Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE.
- Minimize potential degradation of the New River by COC-affected groundwater.

The cleanup levels for OU 14 are presented in **Table 14-1**.

14.4 Remedial Actions

The OU 14 RAs and expected outcomes are summarized in **Table 14-2**. The RA for OU 14 includes the following major components:

- Constructing a multi-layered cap to prevent potential exposure to buried wastes and contaminated soil and provide a barrier to minimize infiltration of surface water.
- LTM of groundwater to assess effectiveness of MNA.
- LUC implementation for buried waste, soil, and groundwater as follows:
 - Prohibit unauthorized intrusive activities within the waste disposal area.
 - Prohibit residential/recreational uses and development including, but not limited to, any form of housing, any kind of school, child-care facilities, playgrounds, and adult nursing facilities.
 - Prohibit human consumption of or interaction with groundwater from the surficial and Castle Hayne aquifers underlying Site 69.
 - Require consideration of the VI pathway for any future construction within the site.
 - Maintain the integrity of any existing or future monitoring or remediation system at the site (including but not limited to the cap, groundwater monitoring wells, fences, and signs).

14-2 ES120414012346RAL

14.4.1 Remedy Implementation

Multi-Layer Cap

Installation of the approximately 5-acre multi-layer cap was completed in September 2014. The components of the cap consist of low-permeability soil and geosynthetics layers and a storm water management system. The cap was vegetated using native grass species to provide long-term erosion protection. The approximate capped area is shown on **Figure 14-1**. Implementation details and final as-built drawings will be provided in the IRACR, expected to be complete in 2015.

Long-term Monitoring and Land Use Controls

LTM at Site 69 was initiated in 1998, discontinued in 2005, and reinstated in 2015 and is currently ongoing as described in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002) and are pending update based on the ROD. The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

14.4.2 Remedy Operation and Maintenance

Multi-Layer Cap

O&M of the cap, conducted quarterly, will consist of site inspections to evaluate general conditions and maintenance needs such as areas that need mowing or reseeding; access and controls such as entrance road, fencing, and signage conditions; and cap conditions such as settlement, cracks, erosion, holes, bulges, vegetation, and wet areas indicating poor drainage. Maintenance activities will include any items identified during site inspections.

Long-term Monitoring

LTM at Site 69 initially consisted of collecting groundwater samples semi-annually from 15 monitoring wells for VOCs and NAIPs. LTM was discontinued in 2005 based on the Supplemental Investigations being conducted. LTM at Site 69 will be re-implemented in 2015 to monitor plume stability and confirm that there are no releases from the waste disposal area or potential impacts to surface water. The LTM program includes nine surficial, 12 UCH, and 6 MCH aquifer monitoring wells. Samples from all wells will be analyzed annually for VOCs and every 5 years for chemical agents, PCBs, and pesticides. Additionally, every five years samples will also be collected from 18 of these wells (12 UCH and 6 MCH aquifer) for metals analysis and 12 of these wells (4 surficial, 4 UCH, and 4 MCH aquifer) for NAIP (MEE, alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon) analysis. NAIPs will be analyzed to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs.

Land Use Controls

Currently, a fence prevents access to the waste disposal areas and the LUCs are being updated to encompass the current extent of contamination. The proposed LUC boundaries are shown on **Figure 14-1** and are summarized in **Table 14-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

At the time of the ROD, an intrusive activities control boundary for MEC was proposed because of the site's location within UXO-02. However, since the ROD was signed, UXO-02 was approved for NFA with respect to MEC (CH2M HILL, 2013c).

TABLE 14-3
OU 14 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	LUCIP	Onslow County Registration Date
	Current LUCs		
Non-Industrial Use Control Boundary	14.6		
Intrusive Activities Control Boundary (Groundwater)	8	July 2002	February 2002
Aquifer Use Control Boundary (1,000 feet)	127.2		
Access Control Boundary	14.6		
	Proposed LUCs		
Industrial/Non-Industrial Use Control Boundary (VI)	15.7		
Intrusive Activities Control Boundary (Soil, Groundwater)	14.6	Proposed	
Aquifer Use Control Boundary	127.2	July 2012	February 2002

14.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in **Table 14-4**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 14-2**.

TABLE 14-4
2010 FYR OU 14 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Date Complete/Current Status
LTM program was discontinued due to supplemental investigation activities in support of a Final ROD	LTM should be reinstituted upon completion of the supplemental investigation to monitor for potential downgradient migration. (2014)	Site 69 is scheduled to be sampled in the LTM program for 2015 upon installation of the LTM well network.

14.5 Technical Assessment

Is the remedy functioning as designed?

Yes. The cap installation was completed in September 2014 (Tetra Tech, 2014). The MNA monitoring well network was installed in February 2015 and the first round of groundwater sampling is planned for June 2015. LUCs are in place to prevent exposure to buried waste and COCs in site media and are being updated.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. Based on reasonably anticipated future land use and a review of updated risk evaluation guidance and current ARARs, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection are still valid.

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 14. A cap was installed to prevent exposure to buried waste and LUCs to prevent exposure to MEC are not necessary based on the NFA determination for UXO-02.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs, as shown in **Table 2-1**, the remedy to maintain LUCs restricts unauthorized activities which may result in exposure to subsurface materials and/or groundwater. Thus, toxicity changes would not affect the

14-4 ES120414012346RAL

protectiveness of the remedy. Additionally, the cleanup goals are the NCGWQS or the MCL, which have not changed since the ROD was signed for Site 69.

An RSL was established for 1,4-dioxane. In 2002, USEPA collected groundwater samples at Site 69 to confirm the presence or absence of 1,4-dioxane. Analytical results were below detection limits (**Attachment C**).

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

14.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 14 during this FYR.

14.7 Statement of Protectiveness

The remedy at OU 14 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through the cap and LUCs. Perimeter fencing restricts access to the waste area at Site 69. The LUCs to restrict soil and groundwater intrusive activities and prohibit non-industrial and aquifer use are protective of human health and the environment because exposure to waste, soil, and groundwater that could result in unacceptable risks is being controlled. MNA will be initiated to monitor plume stability and confirm that there are no releases from the waste disposal area or potential impacts to surface water.

14.8 References

CH2M HILL. 2010. Five-Year Review, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. August.

CH2M HILL, 2011. Supplemental Investigation Site 69, Operable Unit No. 14 – Rifle Range Chemical Dump. Marine Corps Base, Camp Lejeune, Jacksonville, North Carolina. August.

CH2M HILL. 2012a. Preliminary Assessment/Site Inspection Report, MMRP Site UXO-02, Unnamed Explosive Contaminated Range, ASR# 2.201, Marine Corps Base Camp Lejeune Jacksonville, North Carolina. October.

CH2M HILL, 2012b. Expanded Site Investigation, Military Munitions Response Program Site UXO-02 – Former Unnamed Explosive Contaminated Range, ASR #2.20. Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. October.

CH2M HILL, 2012c. Feasibility Study, Site 69, Operable Unit No. 14. Marine Corps Base, Camp Lejeune, Jacksonville, North Carolina. April.

CH2M HILL, 2012d. Proposed Remedial Action Plan, Site 69; Operable Unit No. 14. Marine Corps Installation East-Marine Corps Base Camp Lejeune, North Carolina. August.

CH2M HILL. 2013a. No Action Decision Document MMRP Sites UXO-01, UXO-02, UXO-07, UXO-08, UXO-10, UXO-11, UXO-17, Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina. May.

CH2M HILL, 2013b. Record of Decision, Operable Unit 14, Site 69. Marine Corps Installation East-Marine Corps Base Camp Lejeune, North Carolina. March.

CH2M HILL. 2013c. After Action Report Munitions Response Activities at Site UXO-02, Former Unnamed Explosive Contaminated Range (ASR# 2.201), Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina. October.

CH2M HILL, 2013d. Remedial Design, Site 69, Operable Unit No. 14. Marine Corps Installation East-Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. February.

TABLE 14-1
Cleanup Levels for OU 14 (Site 69)
2015 Five-Year Review
Camp Lejeune, North Carolina

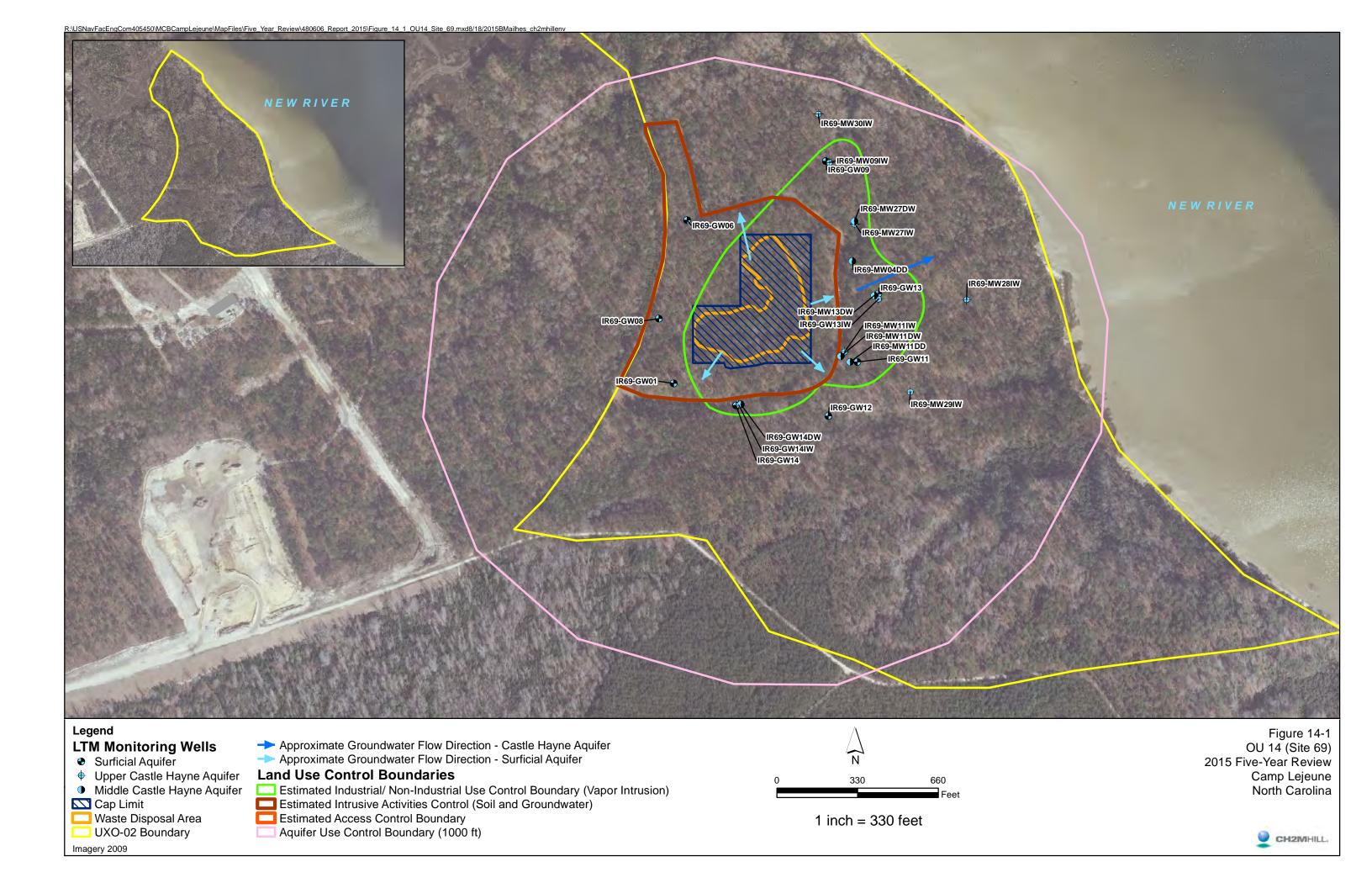
84-41-	200-	ROD Cleanup Levels	Current Cle	eanup Level		
Media	COCs	(CH2M HILL, 2013b)	Concentration	Reference		
	VOCs	•				
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS		
	1,1,2-Trichloroethane	5	5	MCL		
	1,2-Dichloroethane	0.4	0.4	NCGWQS		
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL		
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL		
	Trichloroethene	3	3	NCGWQS		
	Vinyl chloride	0.03	0.03	NCGWQS		
Groundwater (μg/L)	Pesticides					
	Alpha-BHC	0.02	0.02	NCGWQS		
	Dieldrin	0.002	0.002	NCGWQS		
	Heptachlor epoxide	0.004	0.004	NCGWQS		
	PCBs					
	Aroclor-1260	0.5	0.5	MCL		
	Metals					
	Chromium	10	10	NCGWQS		
	Thallium	2	2	MCL		

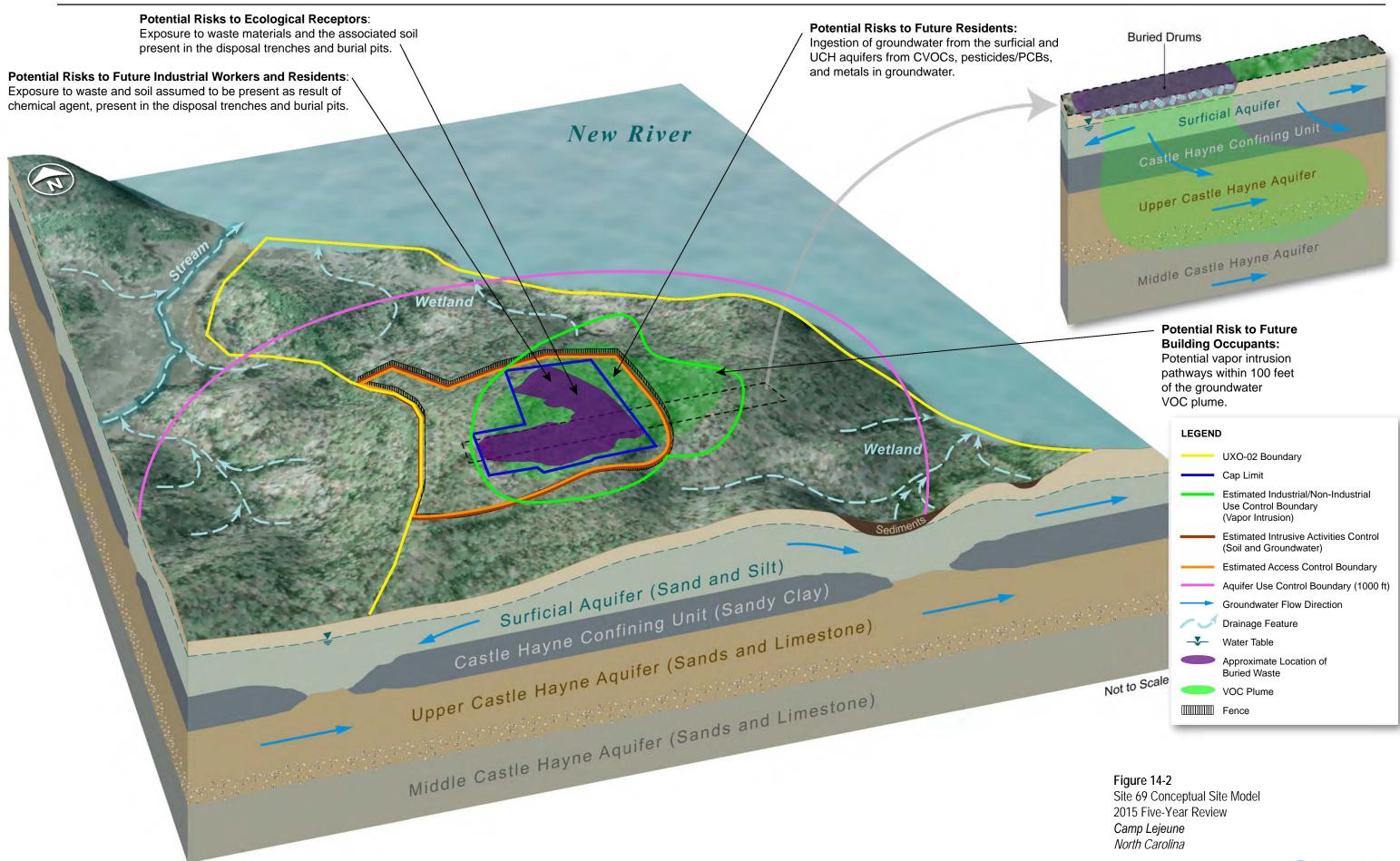
Cleanup Level Reference Dates:

MCL (May 2009) NCGWQS (April 2013) RSL (November 2014)

TABLE 14-2
OU 14 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome	
	I	Potential unacceptable risks to human health and the	· · · · · · · · · · · · · · · · · · ·		Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE. Minimize exposure to potential chemical agent and chemical waste to the maximum extent practicable.	LUCs	Maintain non-industrial and intrusive activities controls and monitor quarterly.	
	associated soil	contaminants (chemical agent) in buried waste and associated soil.		Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE. Minimize exposure to potential chemical agent and chemical waste to the maximum	Capping	Maintain multi-layered cap to provide a barrier for receptors and evaluate effectiveness annually by comparison of current COC concentrations in downgradient monitoring wells to preconstruction		
				extent practicable. Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable.		concentrations and the cleanup levels.	Restricted/	
69	Groundwater	Potential unacceptable risks to future industrial or residential receptors from exposure to VOCs, pesticides, PCBs and metals in groundwater and		Minimize potential degradation of the New River by COC-affected groundwater. Restore groundwater quality at Site 69 to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.	MNA/LTM	Implement MNA/LTM to monitor COC concentrations and migration until each groundwater COC is at or below its respective cleanup level for 4 consecutive monitoring events. If concentrations of COCs exceed ten times the NCSWQS at locations adjacent to surface water bodies, surface water monitoring will be initiated.	Industrial Land Use	
	metals in groundwater and VOCs in indoor air through vapor intrusion.			Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE. Minimize exposure to potential chemical agent and chemical waste to the maximum extent practicable.	LUCs	Maintain intrusive activities and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.		





Operable Unit 16 (Sites 89 and 93)

15.1 Site History and Background

OU 16 is within in the Camp Geiger operations area at MCAS New River and covers approximately 66 acres (**Figure 1-2**). OU 16 consists of two sites (Sites 89 and 93) that have been grouped together because of their proximity to one another and unique characteristic of suspected waste (solvents).

Site 89 — the former **DRMO** is approximately 50 acres and is located west of the New River, near the intersection of 8th and G Streets (Figure 15-1). The Base motor pool operated on the site until 1988 and reportedly used solvents such as acetone, TCE, and 2-butanone (methyl-ethyl-ketone) for cleaning parts and equipment. A steel 550-gallon UST was used to store waste oil from 1983 until its removal in 1993. During removal, visible signs of contamination were observed and the contaminated soil was removed until groundwater was encountered. Other structures historically located in the former UST area include Building STC-867, which was reportedly used to store soil piles from various on-Base sources, and a wash rack with an associated drain and OWS. The DRMO was operated by the Defense Logistics Agency on the site from 1988 until 2000. The area was used as a storage yard for items such as scrap and surplus metal, electronic equipment, vehicles, rubber tires, and fuel bladders. The site has been vacant since the DRMO relocated in 2000.

Site 93 — Building TC942 is approximately 16 acres located at the intersection of 9th and E Streets (Figure 15-1). Historical records indicate that a 550-gallon UST storing waste oil was previously located on Site 93, off the southwest corner of Building TC-942. The UST was permanently closed in December 1993.

15.2 Site Characterization

The findings from various investigations at OU 16 that are pertinent to the FYR are summarized below.

15.2.1 Physical Characteristics

 Surface Features – At Site 89, the former DRMO area is surrounded by a fence with an access gate, and the ground surface is covered with asphalt pavement, gravel, or grass. The area north of the former DRMO is developed,

1994	•UST Investigation (Site 89)
1995- 1996	•Geotechnical Investigation (Site 93)
1996- 1998	•RI (Site 89 & 93)
1999- 2003	•Groundwater Monitoring (Site 89)
1999	•Post RI (Site 89)
2000	•Low Temperature Thermal Desorption TCRA (Site 89)
2001	•Supplemental Investigation (Site 89), Natural Attenuation Evaluation (Site 89)
2002	•Additional Plume Characterization (Site 93)
2003- 2005	•Electrical Resistive Heating Pilot Study (Site 89)
2004- 2005	•Supplemental Investigation (Site 93)
2005	•FS (Site 93)
2006	•PRAP and IROD (Site 93)
2006- 2008	•Comprehensive RI (Site 89)
2006- 2008	•Treatability Study (Site 89)
2006- 2008	•RD/RA - ISCO (Site 93)
2007- 2010	•NTCRA – Soil Mixing (Site 89)
2007- 2011	Basewide VI Evaluation
2008- resent	•LTM (Site 93)
2008	Baseline ERA Addendum (Site 89)
2009	•RIP and IRACR (Site 93)
2009- 2010	•NTCRA – Western Wetland Soil Removal (Site 89)
2011- 2012	•FS (Site 89)
2012	•PRAP, ROD, RD (Site 89)
2013	•RA (AS System, Aerator, and PRB Site 89)

with buildings, asphalt pavement, and maintained grass. The area to the west and south of the former DRMO is primarily wetland along Edwards Creek. The eastern portion of Site 89 is generally undeveloped and covered in grass, wetland, and forest.

Site 93 is developed and covered with asphalt pavement, gravel, and grass, although the eastern portion of the site is wooded and slopes gently toward Edwards Creek. Storm water from Camp Geiger is conveyed by manmade drainage ditches into the headwaters of Edwards Creek.

• Geology and Hydrogeology – Subsurface conditions generally consist of Coastal Plain deposits including silts, clays, fine sands, and limestone (Baker, 1998). A discontinuous layer of dense fine sands, silts, and clays provides localized areas of confinement of the Castle Hayne aquifer. Where the confining layer is absent, the surficial and Castle Hayne aquifers are in direct hydraulic communication. Groundwater is typically encountered at depths ranging from approximately 1 to 14 feet bgs. In general, the groundwater flow direction within the surficial and Castle Hayne aquifers at both sites is to the southeast towards Edwards Creek and the New River. The surficial aquifer extends from the water table to a depth of approximately 25 feet bgs where the Castle Hayne confining unit is encountered at thicknesses of 20 to 40 feet.

15.2.2 Land Use

- Current Land Use There are no ongoing operations at Site 89. An access road that bisects the site is used by
 military personnel for recreation, training, and to access a picnic area located adjacent to the New River.
 Buildings in the vicinity of Site 93 currently function as classrooms, barracks, and supply rooms for the Marine
 Infantry School.
- Future Land Use There are no anticipated changes in land use.

15.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD.

Site 89

Site 89 was initially characterized in 1997 as part of the OU 16 RI (Baker, 1998). VOCs were detected in soil and surficial groundwater and PAHs and pesticides were detected in soil and sediment. Following the RI, the site was placed in the LTM program. After the initial round of LTM in 1999, concentrations of VOCs, particularly CVOCs, were several orders of magnitude higher than initially detected and as a result, the Immediate Response Investigation (Baker 1999) was implemented to delineate the COC impacts to soil, groundwater, and surface water. Several removal actions to remove the source-level concentrations of VOCs in soil and groundwater were implemented prior to the 2008 Site 89 RI (CH2M HILL, 2008) and are discussed in Section 15.2.4. In preparation for the FS (CH2M HILL 2012a), a site-wide groundwater sampling event was conducted in 2008, a fate and transport study was completed in 2009, and another round of site groundwater sampling was conducted in 2010. The following is a summary of the site characteristics and risks at the time of the ROD (CH2M HILL, 2012b). The HHRA and ERA were updated based on the nature and extent of contamination after the interim measures were completed.

- CVOCs are the primary contaminant in surficial and UCH groundwater and surface water.
- An HHRA and ERA were completed for Site 89 during the Comprehensive RI (CH2M HILL, 2008) and updated during the FS based on the 2010 site-wide groundwater sampling results and data collected during the IRAs. No potential unacceptable human health risks were identified based on current land use. Potential unacceptable human health risks were identified for future industrial workers and residents from 1,1,2,2-PCA, 1,1,2-TCA, cis-1,2-DCE, PCE, trans-1,2-DCE, TCE, and VC in groundwater or in indoor air associated with VI from groundwater (Figure 15-2). Potential unacceptable ecological risks were identified from PAHs and pesticides at two isolated locations within the wetland at Site 89.

15-2 ES120414012346RAL

Site 93

- During the OU 16 RI (Baker, 1998), the Additional Plume Characterization (Baker, 2002) and the Supplemental Site Investigation (CH2M HILL, 2005), VOCs and metals were detected in groundwater and surface water.
- An HHRA and ERA were completed for Site 93 during the OU 16 RI. No potential unacceptable human health
 risks were identified based on current land use. Potential unacceptable risks were identified for future
 residents from arsenic, manganese, cis-1,2-DCE, and PCE in groundwater (Figure 15-3). Metals were not
 retained as COCs because they were suspected to be a result of natural conditions and not site operations
 (CH2M HILL, 2006). No unacceptable ecological risks were identified.

15.2.4 Interim Removal Actions

Several removal actions and pilot studies were completed at Site 89 to reduce or eliminate risks and contaminant volume, particularly dense non-aqueous phase liquid (DNAPL) in soil and groundwater identified after the 1998 RI was completed prior to the ROD (2012) (**Figure 15-2**).

- Low Temperature Thermal Desorption TCRA (OHM, 2000): Based on the results of the Immediate Response Investigation and supplemental sampling (Baker, 1999), DNAPL in shallow soil in the southern portion of the DRMO Area was identified as a source of VOC contamination in the surficial groundwater and Edwards Creek. In 2000, A TCRA consisting of low-temperature thermal desorption was completed in the southern portion of the former DRMO for the removal and treatment of vadose zone soils contaminated with chlorinated solvents. Roughly 32,000 tons of DNAPL-impacted soil were treated. In addition, an aeration system was installed in Edwards Creek to assist in the remediation of VOCs. The aeration system remains in place and is operational.
- Electrical Resistive Heating (ERH) Pilot Study (CH2M HILL and Baker, 2002): Based on the results of supplemental investigations conducted in 2000 and 2001 (Baker, 1999 and CH2M HILL, Baker, and CDM, 2001), an ERH pilot study was conducted from 2003 to 2004 to treat the DNAPL in surficial groundwater and soil in the southern area of the DRMO. The total treatment area was approximately 15,900 square feet, and the approximate quantity of soil treated was 14,700 cubic yards, based on an estimated conductive zone of 25 feet. An estimated 48,000 pounds of VOCs were removed from the subsurface. Confirmatory sampling indicated that the free-phase DNAPL in the treatment zone was removed.
- Treatability Studies (AGVIQ-CH2M HILL Joint Venture, 2008): From 2006 to 2008, a treatability study was
 completed to evaluate the performance and effectiveness of four technologies to remove CVOCs from
 surficial groundwater, including: AS using a HDD well; permeable reactive barriers (PRB) using mulch and
 compost as backfill; chemical reduction via zero-valent iron (ZVI) injection through pneumatic fractures; and
 ERD using a combination of sodium lactate and EVO using DPT injection methods. Evaluation of the four pilot
 studies concluded that AS is the optimal treatment when taking into account effectiveness, implementability,
 and cost.
- NTCRA Zero Valent Iron (AGVIQ-CH2M HILL Joint Venture, 2010): In 2008, an NTCRA consisting of soil
 mixing with ZVI and clay was conducted in the southern portion of the former DRMO, outside of the ERH
 treatment area, to remove chlorinated solvents in the soil and surficial aquifer groundwater. The area treated
 was 32,000 square feet at a depth of 25 feet, resulting in a total treated volume of 30,000 cubic yards. Followup monitoring has indicated significant reduction in VOC concentrations in the soil, groundwater, and
 adjacent creek.
- NTCRA Western Wetland (CH2M HILL, 2010): In 2010, an NTCRA consisting of soil and sediment excavation
 and offsite disposal was completed in the western wetland to remove ecological risks associated with PAHs
 and pesticides. After excavation, confirmation sampling was conducted and the results were below cleanup
 levels. Excavated soil was disposed of offsite.

The ROD was prepared based on the site conditions after these interim measures were completed.

15.3 Remedial Action Objectives

Site 89

The ROD addressing groundwater and surface water at Site 89 was signed in December 2012 (CH2M HILL, 2012b). The RAOs identified for Site 89 are:

- Restore groundwater quality at Site 89 to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A NCAC 02L.0201.
- Minimize degradation of Edwards Creek from COC-impacted groundwater discharging into surface water until surface water COC concentrations meet the NCSWQS.
- Control exposure to COCs in groundwater and VI from COCs in groundwater.

The cleanup levels for Site 89 are presented in **Table 15-1**.

Site 93

The ROD addressing groundwater at Site 93 was signed in October 2006 (CH2M HILL, 2006). The RAOs identified for Site 93 are:

- Reduce COC concentrations in the highest concentration areas and reduce exceedances of COCs to meet the NCGWQS or MCLs, whichever is more conservative.
- Prevent human exposure of water containing COCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC) at concentrations above NCGWQS or MCLs, whichever is more conservative.
- Achieve suitability of Site 93 groundwater for unlimited use with a reasonable approach and within a reasonable timeframe.

The cleanup levels for Site 93 are presented in **Table 15-2**.

15.4 Remedial Actions

The OU 16 RA components and expected outcomes are summarized in Table 15-3.

Site 89

The RA at Site 89 includes the following major components:

- AS using horizontal and vertical wells to treat areas of groundwater with high contaminant concentrations (1,1,2,2-PCA greater than 2,000 μg/L, TCE greater than 3,000 μg/L, and VC greater than 3,000 μg/L) and associated performance monitoring.
- PRBs to treat the downgradient groundwater prior to migration offsite or discharge to Edwards Creek and associated performance monitoring.
- Aerators to treat groundwater discharge to surface water and associated performance monitoring.
- MNA to monitor plume stability and natural attenuation processes across the site.
- LUC implementation for groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the aquifers (surficial and Castle Hayne) within 1,000 feet of the groundwater plume.
 - Require consideration of VI pathway for future buildings and land use.
 - Restrict intrusive activities within the extent of the current groundwater contamination unless specifically approved by both NCDENR and USEPA.
 - Maintain the integrity of any current or future remedial or monitoring system such as monitoring wells.

15-4 ES120414012346RAL

Site 93

The RA for Site 93 includes the following major components:

- ISCO via permanganate injection to treat the highest concentration area of the plume.
- LTM of groundwater to assess effectiveness of MNA.
- LUC implementation for groundwater as follows:
 - Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the aquifers (surficial and Castle Hayne) within 1,000 feet of the groundwater plume.
 - Restrict intrusive activities within the extent of the current groundwater contamination unless specifically approved by both NCDENR and USEPA.
 - Maintain the integrity of any current or future remedial or monitoring system such as monitoring wells.

15.4.1 Remedy Implementation

Remedy components for both Site 89 and 93 are shown on Figure 15-1.

Site 89

Air Sparging

In March 2013, two HDD AS wells (HAS-A and HAS-B), and three vertical AS wells (VAS-1, VAS-2, and VAS-3) were installed in the former DRMO (CH2M HILL, 2012 and Osage, 2014) as follows:

Well	Туре	Depth (ft bgs)	Total Length (ft)	Screen Length (ft)	Air Flow Rate (scfm)
HAS-A	HDD	45	910	700	420
HAS-B	HDD	45	840	600	360
VAS-1	Vertical	85	_	2.5	30
VAS-2	Vertical	85	_	2.5	30
VAS-3	Vertical	85	_	2.5	30

Construction details for the AS system are provided in the Construction Completion Report (Osage, 2014). The AS system start-up began in September 2013, performance monitoring began in May 2013 with the baseline sampling, and is ongoing.

Permeable Reactive Barriers

In July 2013, two PRBs were installed east of White Street. PRB A, oriented parallel to White Street, was installed to 35 feet deep to treat groundwater migrating from the source area. PRB B, oriented parallel to Edwards Creek, was installed to 23 feet deep to treat surficial aquifer groundwater before discharging into the creek. The PRB media consisted of a mix of 40 percent mulch and 60 percent gravel (SEPI, 2014). PRB performance monitoring began in December 2013 and is ongoing.

Surface Water Aerators

In January 2014, five in-creek aerators were installed in Edwards Creek to treat VOCs in surface water. Air is delivered at a rate of 50 cubic feet per minute (cfm) and 6 pounds per square inch (psi) via 2,100 feet of conveyance piping to the 5 aerators. The aerators use air stripping technology to transfer contaminants from aqueous solutions to air (SEPI, 2014). Performance monitoring of the 6 in-creek aerators (one existing, five newly installed) began in December 2013 and is ongoing.

Monitored Natural Attenuation and Land Use Controls

MNA of groundwater and surface water at Site 89 was initiated in 2014 and is ongoing. LUCs for Site 89 were updated in 2013. The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

Site 93

In-Situ Chemical Oxidation

The ISCO injections were conducted at Site 93 from 2006 through 2008. The initial phase was conducted from October 2006 to February 2007 and the second phase was conducted from June to December 2007. The injections were suspended due to wet conditions and low actual injection rates compared with the design. During the interval between the first and second phase, pump testing was completed and the injection method was re-evaluated and gravity-feed via injection points was initiated during the second phase. A total of 92,000 and 144,000 gallons of permanganate solution were injected during the first and second phases, respectively, which is approximately 60 percent of the design. Performance monitoring indicated that only a slight reduction in COC concentrations was observed within the treatment area (Shaw 2009). Additional ISCO injections were not considered cost-effective and MNA was initiated.

Long-term Monitoring and Land Use Controls

LTM at Site 93 was initiated in 2008, upon completion of the ISCO injections, and is ongoing as described in the following section. LUCs for Site 93 were implemented in 2009 and updated in 2014 to include VI considerations (CH2M HILL, 2014). The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

15.4.2 Remedy Operation and Maintenance

Site 89

Air Sparging

O&M of the AS system is conducted weekly. Monthly reports are provided to the Navy and the operating parameters and monitoring data are reviewed quarterly by the Partnering Team. **Figures 15-4** and **15-5** summarize AS operating parameters in comparison to the design during the first year of implementation. VAS-3 and HAS-A were turned off for extended periods of time due to observations of daylighting of groundwater and air. In an effort to reduce daylighting and increase flowrates, threaded caps were installed, historical boreholes were abandoned, and the system was turned off in December 2014 to allow the formation to settle and the groundwater levels to equilibrate; in January 2015, the system was restarted at a low flowrate and gradually increased in an effort to achieve higher operating values. Performance monitoring of the AS system currently includes quarterly sampling of 26 monitoring wells (13 surficial aquifer, 12 UCH aquifer, and 1 MCH aquifer monitoring wells) and 2 soil gas sample locations for VOC analysis.

AS system effectiveness is evaluated by comparing COC concentrations in treatment area monitoring wells to pretreatment concentrations and the cleanup levels. The system will operate until at least one of the following conditions has been achieved:

- A COC reduction to 100 μ g/L in samples collected from wells within 50 feet of the sparging system (source area wells) that are part of the AS performance monitoring or MNA networks
- Average COC reduction in source area wells demonstrating an asymptotic trend prior to achieving the target concentrations

After the system has been shut down, MNA will be continued as the remedy until RAOs have been achieved.

Permeable Reactive Barriers

Performance monitoring for the PRBs was initiated in 2013 and includes quarterly sampling for geochemical parameters only for the first year and semi-annual sampling for analysis for VOCs of 21 monitoring wells

15-6 ES120414012346RAL

(19 surficial aquifer and 2 UCH aquifer monitoring wells) for the first two years. Groundwater elevations are measured during all sampling activities.

PRB effectiveness is evaluated quarterly by comparing COC concentrations and geochemical parameters to baseline conditions. Replenishment options will be considered if COC concentrations in upgradient groundwater continue to exceed clean up levels (i.e., groundwater that will be treated by the PRB), concentrations in downgradient groundwater begin to increase or exceed cleanup levels, conditions in the PRB are no longer reducing, and/or TOC within the PRB has been depleted. It is no longer necessary for the PRB to be replenished when concentrations of COCs are detected in PRB performance monitoring wells below the cleanup levels for four consecutive sampling events.

Surface Water Aerators

O&M of the surface water aerators is conducted monthly. Monthly reports are provided to the Navy and the operating parameters and monitoring data are reviewed quarterly by the Partnering Team. Aerator performance monitoring currently includes quarterly sampling of 3 surface water sample locations for VOC COCs. The aerators will remain in operation until COCs in groundwater and surface water are below surface water cleanup levels.

Monitored Natural Attenuation

MNA for Site 89 currently includes 20 surficial, 12 UCH, and 4 MCH aquifer monitoring wells and 5 surface water sample locations. Samples are analyzed annually for VOCs and every five years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs.

Land Use Controls

The LUCs for Site 89 are shown on **Figure 15-1** and are summarized in **Table 15-4**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

The annual O&M cost for the active remedy at Site 89 is estimated at \$120,000. The annual cost of MNA and performance monitoring at Site 89 is approximately \$265,000.

TABLE 15-4
OU 16 (Site 89) Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Industrial/ Non-Industrial Use Control Boundary (VI)	29.1		
Intrusive Activities Control Boundary (Groundwater)	29.1	November 2012 (RD)	November 2013
Aquifer Use Control Boundary (1,000 feet)	105.2		
Access Control	1,600 feet of fence line		

Site 93

Long-term Monitoring

LTM of MNA for Site 93 currently includes 10 surficial and three UCH aquifer monitoring wells. Samples are analyzed annually for VOCs and every five years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. In December 2013, a sample from IR93-MW06 was analyzed for *dehalococcoides* (DHC) and functional genes to evaluate the potential for reductive dechlorination. Sampling locations are shown on **Figure 15-1**.

The RA is evaluated annually, taking into consideration optimization opportunities and the path towards site closure. In 2013, the use of PDBs was initiated for VOC sampling to minimize generation of remediation-derived waste, equipment use, and overall field efforts (CH2M HILL, 2014b). In December 2014, a monitoring well was installed in the surficial aquifer to monitor downgradient plume migration and was added to the LTM network for FY 2015.

The annual cost of LTM at Site 93 is approximately \$45,000.

Land Use Controls

The LUCs for Site 93 are shown on **Figure 15-1** and are summarized in **Table 15-5**. LUCs and general site conditions inspections are conducted quarterly by the Base (**Appendix A**). No LUC intrusions were identified during these site inspections. A visual inspection of the site was conducted in March 2014 in preparation for the FYR. No issues were identified as part of this inspection (**Appendix B**).

TABLE 15-5
OU 16 (Site 93) Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Industrial/Non-Industrial Use Control Boundary (VI)	8.63		
Intrusive Activities Control Boundary (Groundwater)	8.63	October 2014	October 2014
Aquifer Use Control Boundary (1,000 feet)	114.76		

15.4.3 Progress Since the 2010 Five-Year Review

Site 89

Since the 2010 FYR, the Site 89 selected remedy was implemented (discussed above). The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 15-2**.

Site 93

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 15-6.

The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 15-3**.

TABLE 15-6
2010 FYR OU 16 (Site 93) Recommendations/Follow-Up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Site 93 cleanup levels have changed since the ROD	Update groundwater COCs and cleanup levels for Site 93 to reflect recent standards. (2011)	Completed in 2011 and ongoing. Cleanup levels are updated regularly during LTM reporting to reflect current NCGWQS/MCL.
Potential for VI pathway	Evaluate and mitigate VI pathway during construction planning (ongoing).	Complete. There is no unacceptable risk from VI based on current land use and a LUC was added for industrial/non-industrial use (VI). If buildings are planned for construction in the vicinity of the VOC groundwater plume, the potential for a VI pathway is evaluated and mitigated if needed. Base Master Planning maintains current groundwater plume data in the GIS, and all construction projects on-Base go through environmental review.

15-8 ES120414012346RAL

15.5 Technical Assessment

Is the remedy functioning as designed?

Site 89

The AS system is not operating at design parameters and data indicate that the system may not be supplying enough air to reach the entire treatment zone. The PRBs are functioning as designed because decreasing concentrations of COCs have been measured in samples collected downgradient from the PRBs and reducing conditions are present within the PRB. Preliminary LTM data for surface water indicate that no COCs are migrating offsite at concentrations above the NCSWQS and the surface water aerators and PRBs are effective.

AS – COC concentrations from baseline to September 2014 are shown on **Figures 15-6** to **15-12**. The concentrations of COCs in samples collected from the surficial aquifer in the northern portion of the treatment area, closest to the air compressor, are decreasing (**Figures 15-6** to **15-9**). However, COC concentrations in the southern portion of the surficial aquifer treatment area appear to be stable to increasing, indicating that the air may not be reaching the distal ends of the pipes. As discussed in **Section 15.4.2**, the system was shut down to allow the formation to equilibrate and a less aggressive start up procedure was initiated in January 2015. Data following the system restart will be used to re-evaluate the system effectiveness at flow rates closer to the design rates. COC concentrations in the UCH and MCH aquifers are stable or decreasing (**Figures 15-10** to **15-12**). The majority of the COC mass is in the surficial aquifer.

Although sub-slab soil gas concentrations have increased since the AS system was turned on, concentrations of COCs in indoor and outdoor air samples were detected at concentrations below the vapor intrusion screening level, indicating the VI pathway is not complete.

PRB – TCE and VC concentrations from 6 to 18 months from installation for select and representative monitoring well clusters are shown on **Figures 15-13** to **15-16**. TCE concentrations in the PRB parallel to White Street decrease with time and distance in relation to the PRB (**Figure 15-13**). VC concentrations are stable upgradient and downgradient from the PRB with a marked decrease within the PRB (**Figure 15-14**) indicating that reductive dechlorination is likely occurring. TCE and VC concentrations in samples collected from performance wells in the PRB parallel to Edwards Creek decrease with time and distance in relation to the PRB (**Figure 15-15** and **15-16**). These trends indicate that the PRB is functioning as designed.

Water quality parameters collected from within the PRBs and downgradient of the PRBs indicate conditions favorable for biodegradation. For example, negative ORP values were observed at all monitoring wells located within the PRB and downgradient of the PRB (**Figure 15-17** and **15-18**). Additionally, DO was generally observed at levels less than 1 mg/L in water purged from these wells. During the most recent sampling event, in-wall TOC measurements ranged from 4.7 mg/L to 17.6 mg/L, with a median value of 6.37 mg/L, while upgradient TOC measurements ranged from 1.32 mg/L to 10.3 mg/L, with a median value of 1.8 mg/L, indicating that carbon has not been depleted and the useful life of the PRB is not complete.

Surface Water Aerators – COCs detected in Edwards Creek at concentrations exceeding the cleanup levels indicate that groundwater from Site 89 is discharging to the creek. As the surface water migrates downstream and passes through the series of aerators, the concentrations are decreasing. No COCs are detected in exceedance of the cleanup level in the most downstream sampling location indicating that the aerators are functioning as designed and contaminated groundwater is not migrating from Edwards Creek to the New River.

MNA – The majority of Site 89 is being impacted by the active treatment systems. **Table 15-7** shows concentrations from the FS and the first round of LTM sampling for MNA at locations that are not affected by the AS system or PRBs. COC concentrations in the surficial aquifer appear to be decreasing or stable with the exception of IR89-MW77, which shows increases in 1,1,2,2-PCA and TCE. This monitoring well is located downgradient from the former soil mixing area and may be affected by the NTCRA. COC concentrations in the UCH and MCH appear to be stable with the exception of the sample collected from IR89-MW36IW, which shows an increase in TCE and cis-1,2-DCE. The presence of daughter products in both the surficial and UCH aquifers indicates that MNA is occurring and trends will be evaluated as data is collected.

TABLE 15-7
Select COC Concentrations at Site 89

Select COC Conce	ntrations at Site 89						
Location	Sidegradient west of the AS wells						
ID	IR89-MW3	2 (Surficial)	IR89-MW3	32IW (UCH)	IR89-MW3	IR89-MW32DW (MCH)	
COC (μg/L)	FS (December 2010)	LTM (September 2014)	FS (December 2010)	LTM (September 2014)	FS (December 2010)	LTM (September 2014)	
1,1,2,2-PCA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
TCE	4.3	1.45	0.5 U	0.5 U	0.5 U	0.5 U	
cis-1,2-DCE	0.68 J	0.346 J	0.5 U	0.5 U	0.5 U	0.5 U	
VC	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	
Location			Downgradient ea	st of White Street			
ID	IR89-MW3	6 (Surficial)	IR89-MW3	B6IW (UCH)	IR89-MW36DW (MCH)		
COC (μg/L)	FS (December 2010)	LTM (September 2014)	FS (December 2010)	LTM (September 2014)	FS (December 2010)	LTM (September 2014)	
1,1,2,2-PCA	0.5 U	0.5 U	0.5 UJ	1 U	0.5 U	0.5 U	
TCE	0.5 U	0.5 U	16 J	106	0.5 U	0.5 U	
cis-1,2-DCE	0.5 U	0.5 U	92 J	150	0.5 U	0.5 U	
VC 0.5 U 0.5 U		0.95 J	1 U	0.5 U	0.5 U		
Location	Downgrad	lient, south of Edwa	ds Creek, east of White Street		Downgradient from soil mixing are		
ID	IR89-MW3	9 (Surficial)	IR89-MW39IW (UCH)		IR89-MW77		
COC (µg/L)	FS (December 2010)	LTM (September 2014)	FS (December 2010)	LTM (September 2014)	FS (December 2010)	LTM (September 2014)	
1,1,2,2-PCA	0.5 U	0.5 U	0.5 U	0.5 U 0.5 U 18 U		284	
TCE	0.28 J	1.67	0.5 U	0.355 J	18 U	81	
cis-1,2-DCE	200	6.28	0.5 U	0.418 J	700	838	
VC	44 8.03 0.5 U 0.5 U 1,000		852				

The NAIP data, collected from outside of the treatment areas but within the plume in the surficial and UCH aquifers, are summarized in **Table 15-8**. Favorable indicators included ORP (negative or less than 50 mV), nitrate (low or not detected), ferrous iron (measurable levels), and sulfate (not detected or low concentrations). Elevated alkalinity provides buffering capacity during degradation. Elevated chloride and methane concentrations measured in some locations in the surficial aquifer are favorable; however, they are significantly lower in the UCH. DO in the surficial aquifer is generally higher than 1 mg/L indicating aerobic conditions, which aren't typically favorable for reductive dechlorination; however, VC can degrade aerobically. TOC in both aquifer zones was low, which may be unfavorable for microbial growth.

LUCs – LUCs remain in place to prohibit aquifer use, require consideration of VI pathway during construction, restrict intrusive activity, and maintain the integrity of remedial or monitoring systems.

Site 93

No. Based on the review of LTM results and pre- and post- ISCO injection data, the remedy at Site 93 is not functioning as designed because concentrations did not decrease as expected after the ISCO injections and MNA conditions appear to be marginal.

15-10 ES120414012346RAL

MNA – Data trends in the former ISCO treatment area (IR93-MW06 and IR93-MW08) show that COC concentrations continue to be stable and exceed cleanup levels (Figures 15-19 to 15-21). Data trends in the downgradient monitoring wells (IR93-MW12 and IR93-MW14) are stable to slightly increasing, indicating the potential for impacting Edwards Creek. In order to evaluate the potential for impacts to Edwards Creek, COC concentrations in samples collected from downgradient monitoring wells (IR93-MW05, IR93-MW12, and IR93-MW14) were compared to ten times the NCSWQS. In the sample collected from IR93-MW14, VC was detected at a concentration of 43.4 μ g/L, which is greater than ten times the NCSWQS of 2.4 μ g/L (24 μ g/L). Edwards Creek is also affected downstream by Site 89 and the entire creek from headwaters to the OU boundary is currently being monitored and actively remediated as part of the Site 89 remedy.

NAIP data collected from monitoring wells located within the plume are summarized in **Table 15-9**. Favorable indicators include ORP (less than 50 mV with one exception), DO, iron, and nitrate. In contrast, the low chloride, methane, and TOC concentrations and high sulfate concentrations do not indicate reductive dechlorination is occurring. The microbial result, 302 cells/mL, is also low, indicating that reductive dechlorination may not occur within a reasonable timeframe.

A pilot study is currently being planned in the ISCO treatment area to evaluate treatment options to improve aquifer conditions for MNA and accelerate degradation at Site 93.

LUCs – LUCs remain in place to prohibit aquifer use, require consideration of VI pathway during construction, restrict intrusive activity, and maintain the integrity of remedial or monitoring systems.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes, based on reasonably anticipated future land use and a review of updated risk evaluation guidance and current ARARs, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection are still valid. Current LUCs are still protective.

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 16.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs, as shown in **Table 2-1**, the remedy to maintain LUCs restricts unauthorized activities that may result in exposure to groundwater until cleanup levels for UU/UE are achieved. Thus, toxicity changes would not affect the protectiveness of the remedy.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

15.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 16 during this FYR.

15.7 Statement of Protectiveness

The remedy at OU 16 for groundwater and surface water will be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. The LUCs are in place to prevent exposure to groundwater, vapor intrusion, and surface water and therefore there is no current exposure. Active remediation is currently being implemented at Site 89 to reduce the contaminant mass in groundwater and surface water; MNA is currently implemented at Site 93 and a pilot study is being implemented to evaluate enhanced reductive dechlorination.

15.8 Reference

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15-12 ES120414012346RAL

TABLE 15-1
Cleanup Levels for OU 16 (Site 89)
2015 Five-Year Review
Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels	Current Cleanup Level				
iviedia	COCS	(CH2M HILL, 2012)	Concentration	Reference			
	VOCs						
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL			
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL			
Groundwater (μg/L)	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS			
Groundwater (μg/L)	1,1,2-Trichloroethane	5	5	MCL			
	Tetrachloroethene	0.7	0.7	NCGWQS			
	Trichloroethene	3	3	NCGWQS			
	Vinyl chloride	0.03	0.03	NCGWQS			
	VOCs						
Surface Water (µg/L)	1,1,2,2-Tetrachloroethane	4	4	NCSWQS			
Surface Water (µg/L)	Trichloroethene	30	30	NCSWQS			
	Vinyl chloride	2.4	2.4	NCSWQS			

Cleanup Level Reference Dates:

MCL (May 2009) NCGWQS (April 2013) NCSWQS (May 2013)

TABLE 15-2
Cleanup Levels for OU 16 (Site 93)
2015 Five-Year Review
Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels	Current Cleanup Level				
iviedia	Cocs	(CH2M HILL, 2006)	Concentration	Reference			
	VOCs						
	1,2-Dichloroethane		0.4	NCGWQS			
	1,2-Dichloroethene		70	NCGWQS			
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL			
Groundwater (μg/L)	trans-1,2-Dichloroethene	70	100	NCGWQS/MCL			
	1,1,2,2-Tetrachloroethane	0.17	0.2	NCGWQS			
	Tetrachloroethene	0.7	0.7	NCGWQS			
	Trichloroethene	2.8	3	NCGWQS			
	Vinyl chloride	0.015	0.03	NCGWQS			

Notes:

-- COC identified post-ROD based on exceedances of current cleanup levels during LTM Cleanup Level Reference Dates:

MCL (May 2009) NCGWQS (April 2013)

TABLE 15-3
OU 16 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
		Potential unacceptable risks to future industrial		Restore groundwater quality at Site 89 to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A NCAC 02L.0201.	Air Sparging	Install and operate the air aparge system until VOC concentrations are at 100 µg/L in samples collected from source area wells, or average COC reductions in source area wells demonstrate an asymptotic trend prior to achieving the target reduction.	
	Groundwater	workers and future residents from exposure to VOCs in groundwater and indoor air through vapor intrusion.			MNA	Implement groundwater MNA to monitor VOC concentrations and migration until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	
				Control exposure to COCs in groundwater and vapor intrusion from COCs in groundwater.	LUCs	Maintain intrusive activities, industrial/non- industrial use (VI) and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	
89	Surface water VOCs in surface water exceed cleanup levels.	Industrial/Vacant		PRB	Install, maintain, and monitor PRB mulch walls to treat groundwater prior to migration offsite or discharge to Edwards Creek until cleanup levels are met for 4 consecutive sampling events.	UU/UE	
			OCs in surface water sceed cleanup levels.	Minimize degradation of Edwards Creek from COC-impacted groundwater discharging into surface water until surface water COC concentrations meet the NCSWQS.	Aerators	Install, maintain, and monitor surface water aerators within Edwards Creek until surface water VOCs are below surface water cleanup levels.	
					LTM	Implement surface water LTM to monitor the effectiveness of the PRB and aerators and VOC concentrations until groundwater LTM/MNA is complete.	
					LUCs	Maintain access controls around Edwards Creek and monitor quarterly until groundwater cleanup levels are achieved.	

TABLE 15-3
OU 16 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
				Reduce COC concentrations in the highest concentration areas and reduce exceedances of COCs to meet the NCGWQS or MCLs, whichever is more conservative.	ISCO	Permanganate injections to treat the highest concentration area of the plume. ISCO injections were conducted from October 2006 to December 2007.	UU/UE
93		Potential unacceptable risks to future industrial workers and future residents from exposure	tential unacceptable ks to future industrial rkers and future idents from exposure VOCs in groundwater d indoor air through por intrusion.	Achieve suitability of Site 93 groundwater for unlimited use with a reasonable approach and within a reasonable timeframe.	MNA	Implement groundwater MNA until each VOC is at or below its respective cleanup level for 4 consecutive sampling events.	
		to VOCs in groundwater and indoor air through vapor intrusion.		Prevent human exposure to water containing COCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) at concentrations above NCGWQS or MCLs, whichever is more conservative.	monitor quarterly until groundwater cleanup	industrial use (VI) and aquifer use controls and monitor quarterly until groundwater cleanup levels	
			Prevent future exposure to COCs in indoor air via the VI pathway.		are achieved.		

TABLE 15-8
Site 89 Summary of NAIPs – June 2014
2015 Five-Year Review
Camp Lejeune, North Carolina

Indicator Parameter	Range of Results	Condition for favorable reductive pathway				
Surficial Aquifer (within plume area)						
ORP (mV)	-121 to 112	Less than +50 mV (favorable) Less than -100 mV (ideal)				
DO (mg/L)	0.0 to 3.25	Less than 1.0 mg/L				
Nitrate (mg/L)	0 to 0.25	Less than 1.0 mg/L				
Ferrous Iron (mg/L)	1.2 to 4	Measurable Levels				
Sulfate (mg/L)	ND to 42.4	Less than 20 mg/L				
Alkalinity (mg/L)	127 to 256	2x Above ¹ Background (125)				
Chloride (mg/L)	7.88 to 260	2x Above ¹ Background (8)				
Methane (μg/L)	69.3 to 5,250	>500 µg/L				
Total Organic Carbon (mg/L)	3.61 to 15.4	>20 mg/L				
UCH Aquifer (within plume area)						
ORP (mV)	-90.7 to 7.3	Less than +50 mV (favorable) Less than -100 mV (ideal)				
DO (mg/L)	0.83 to 1.7	Less than 1.0 mg/L				
Nitrate (mg/L)	0	Less than 1.0 mg/L				
Ferrous Iron (mg/L)	0 to 0.2	Measurable Levels				
Sulfate (mg/L)	ND to 7.41	Less than 20 mg/L				
Alkalinity (mg/L)	176 to 238	2x Above ¹ Background (237)				
Chloride (mg/L)	7.48 to 11.7	2x Above ¹ Background (9.4)				
Methane (μg/L)	8.02 to 74.7	>500 μg/L				
Total Organic Carbon (mg/L)	1.38 to 4.18	>20 mg/L				

Notes:

¹Background data from monitoring wells outside of historical plume area:

Surficial - IR89-MW35, IR89-MW41 UCH - IR89-MW32IW, IR89-MW41IW

TABLE 15-9
Site 93 Summary of NAIPs - December 2013
2015 Five-Year Review

Camp Lejeune, North Carolina

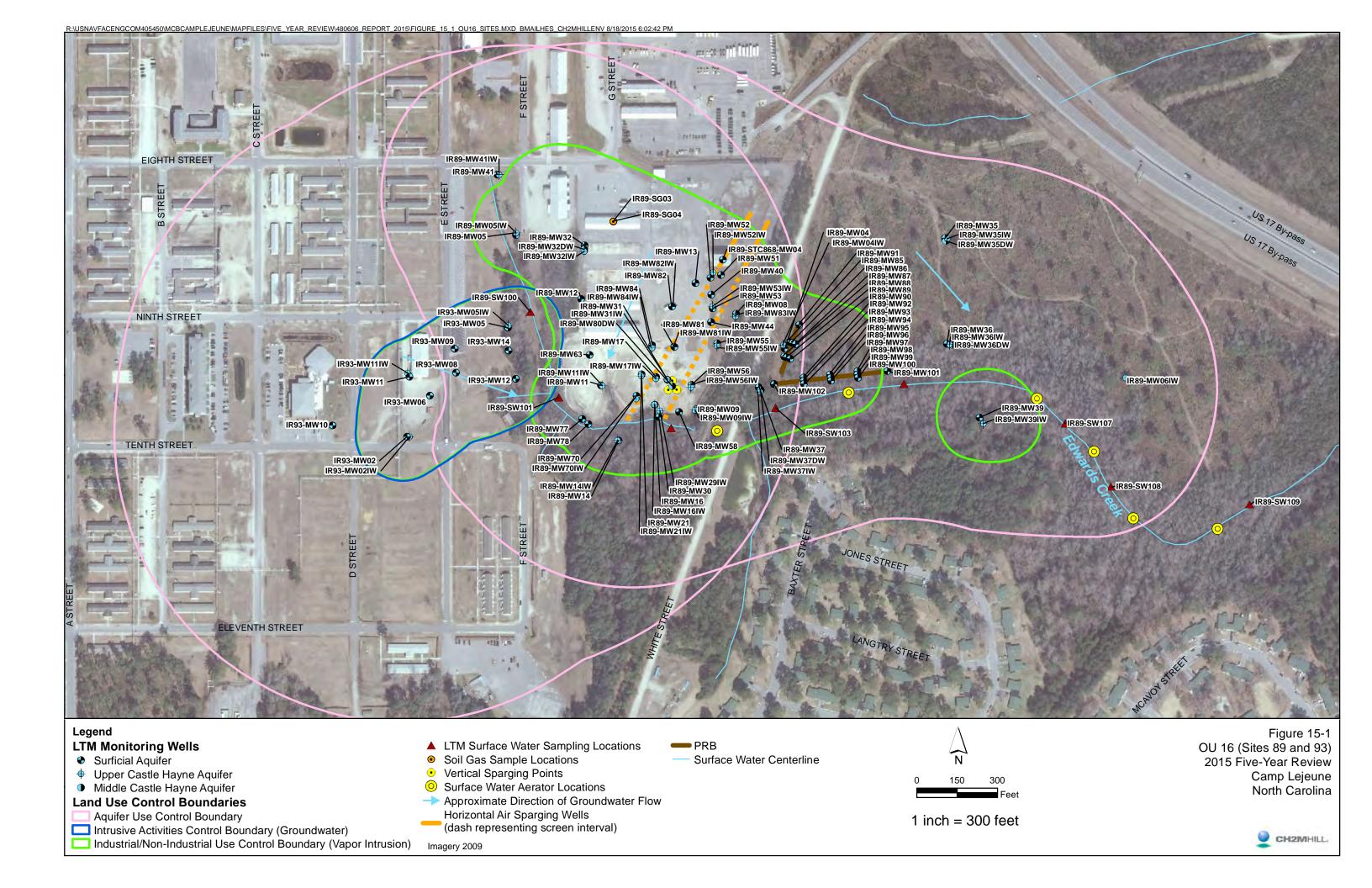
Indicator Parameter	Range of Results	Condition for favorable reductive pathway				
Surficial Aquifer (within plume area)						
ORP (mV)	-120.8 to 230.2	Less than +50 mV (favorable) Less than -100 mV (ideal)				
DO (mg/L)	0.11 to 0.48	Less than 1.0 mg/L				
Nitrate (mg/L)	0	Less than 1.0 mg/L				
Ferrous Iron (mg/L)	1 to 3	Measurable Levels				
Sulfate (mg/L)	17.5 to 140	Less than 20 mg/L				
Alkalinity (mg/L)	<1 to 211, average 133	2x Above ¹ Background (248)				
Chloride (mg/L)	0.33 to 25.8, average 10	2x Above ¹ Background (9)				
Methane (μg/L)	47.3 to 554	>500 μg/L				
Total Organic Carbon (mg/L)	1.46 to 3.14	>20 mg/L				
Microbial (cells/mL)- IR93-MW06	302	10 [^] 3 and higher				
UCH Aquifer (within plume area)						
ORP (mV)	-101	Less than +50 mV (favorable) Less than -100 mV (ideal)				
DO (mg/L)	0.72	Less than 1.0 mg/L				
Nitrate (mg/L)	0	Less than 1.0 mg/L				
Ferrous Iron (mg/L)	1.6	Measurable Levels				
Sulfate (mg/L)	2.01	Less than 20 mg/L				
Alkalinity (mg/L)	224	2x Above ¹ Background (227)				
Chloride (mg/L)	7.85	2x Above ¹ Background (9)				
Methane (μg/L)	173	>500 µg/L				
Total Organic Carbon (mg/L)	2.97	>20 mg/L				

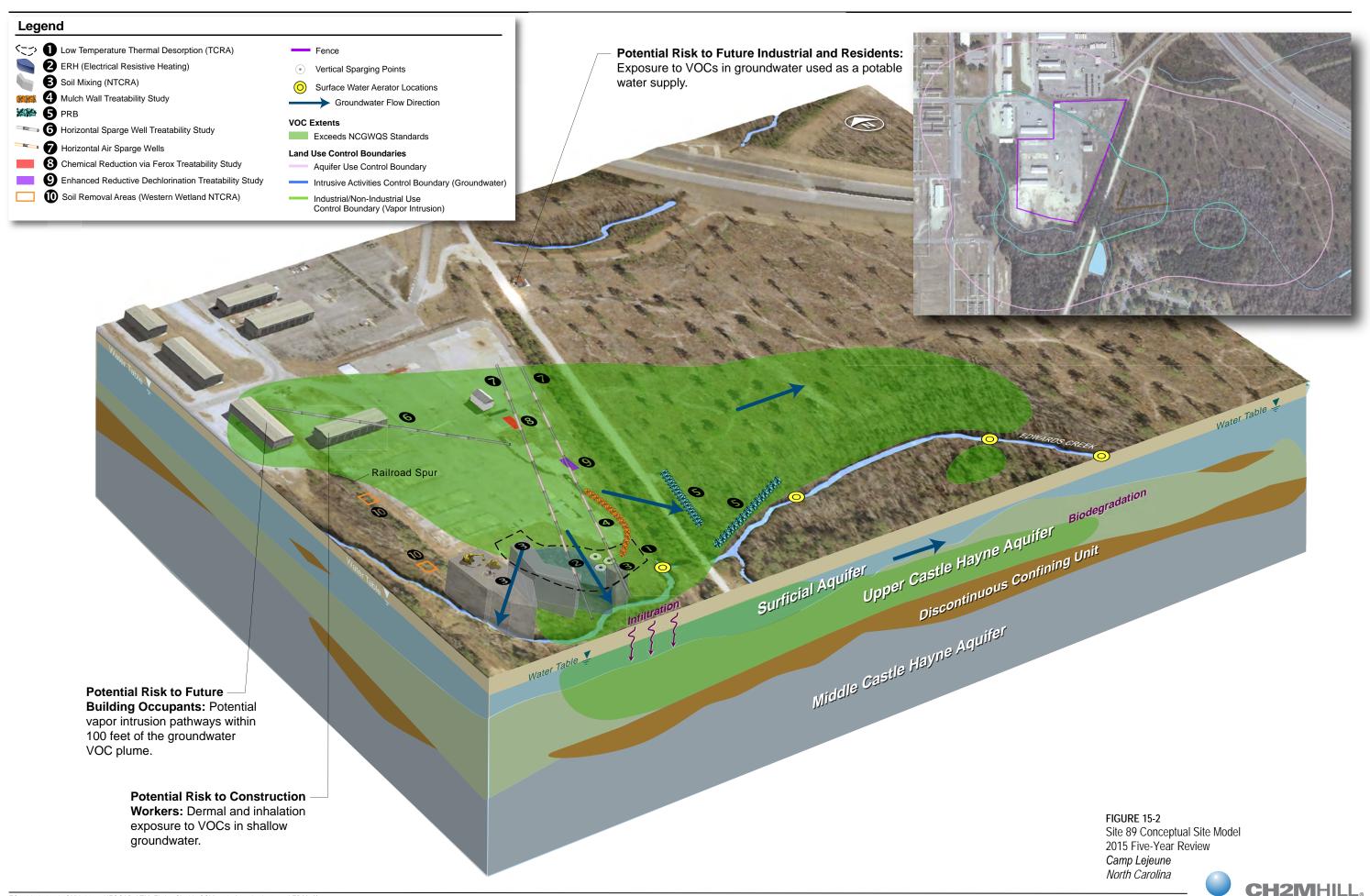
Notes:

¹Background data from monitoring wells outside of historical plume area:

Surficial - IR89-MW41

UCH - IR93-MW05IW, IR93-MW11IW





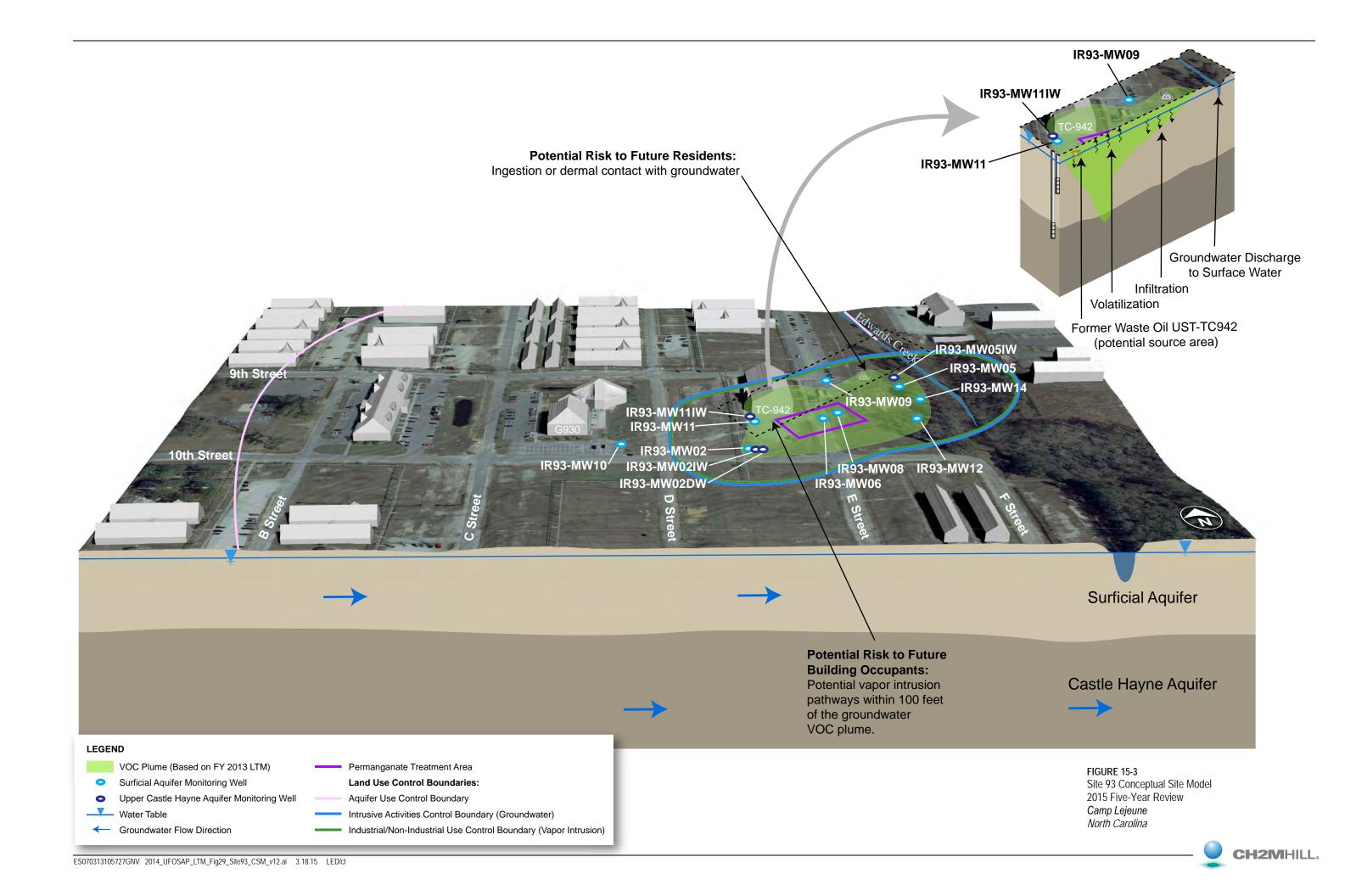


Figure 15-4 HAS Operating Parameters 2015 Five-Year Review Camp Lejeune, North Carolina

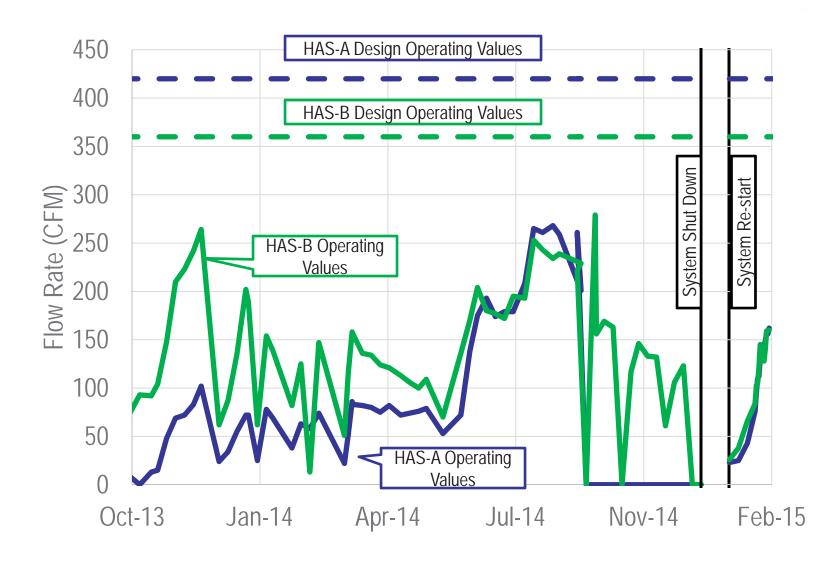
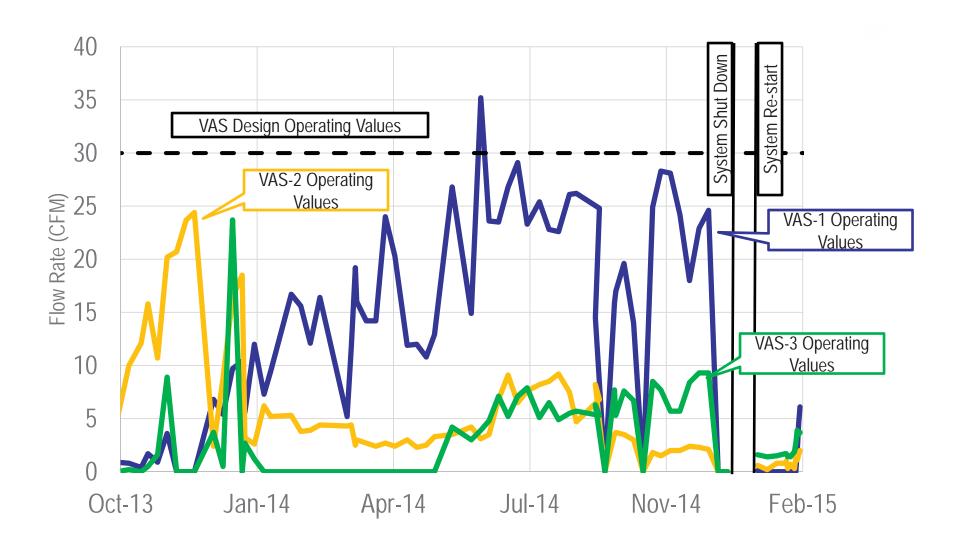
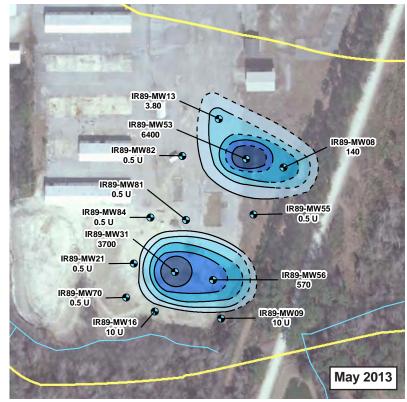
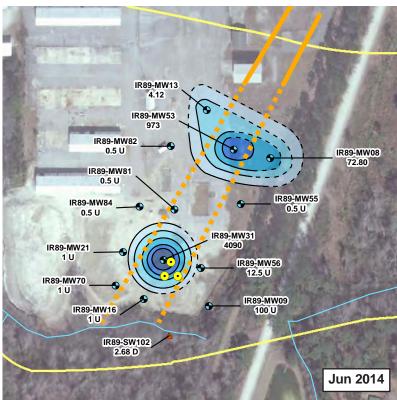
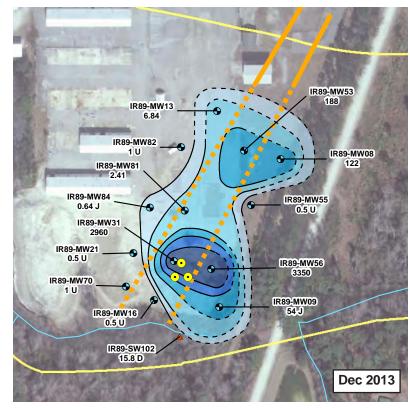


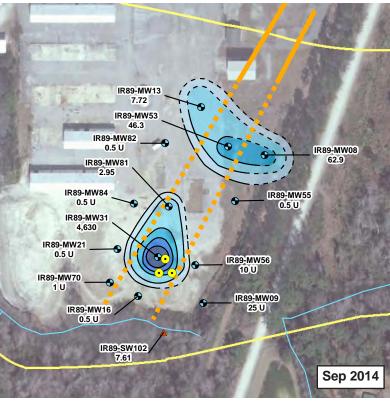
Figure 15-5 VAS Operating Parameters 2015 Five-Year Review Camp Lejeune, North Carolina

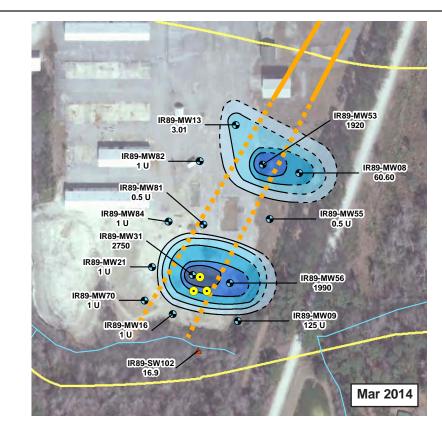












Legend

Monitoring Well

▲ Surface Water Sample

Vertical Sparging Points

Horizontal Air Sparging Wells
(dash representing screen interval)

Stream

Site 89 Boundary

1,1,2,2-PCA Extent (dashed where inferred)

0.2 μg/L - 2 μg/L

2 μg/L - 20 μg/L

20 μg/L - 200 μg/L

200 μg/L - 2,000 μg/L

2,000 μg/L - 20,000 μg/L

Notes:

PCA - Tetrachloroethane

1,1,2,2-PCA NCGWQS - 0.2 μg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentrations is estimated

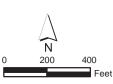
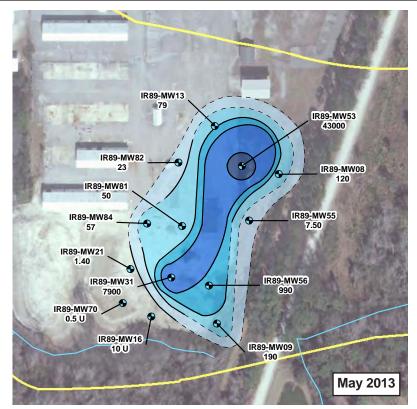
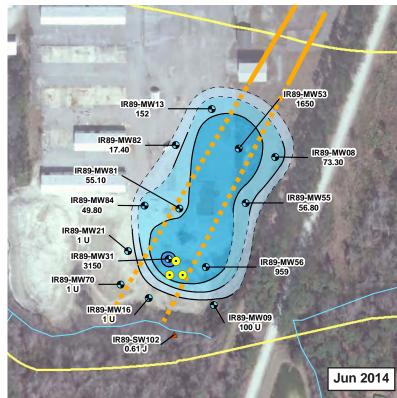
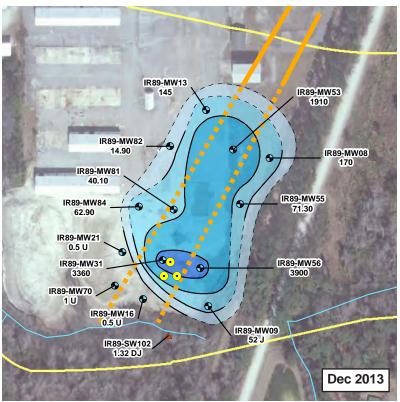


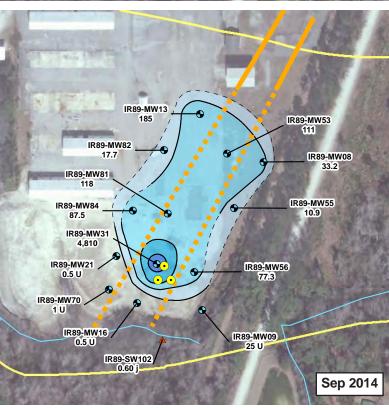
Figure 15-6 Site 89 Approximate Extent of 1,1,2,2-PCA Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina

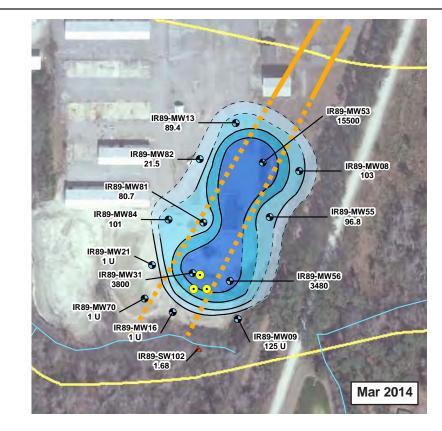












Monitoring Well

▲ Surface Water Sample

Vertical Sparging Points

Horizontal Air Sparging Wells
(dash representing screen interval)

Stream

Site 89 Boundary

TCE Extent (dashed where inferred)

3 μg/L - 30 μg/L

30 μg/L - 300 μg/L

300 µg/L - 3,000 µg/L 3,000 µg/L - 30,000 µg/L

3,000 μg/L - 30,000 μg/L 30,000 μg/L - 300,000 μg/L Notes:

TCE - Trichloroethene

TCE NCGWQS - 3 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

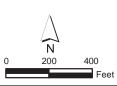
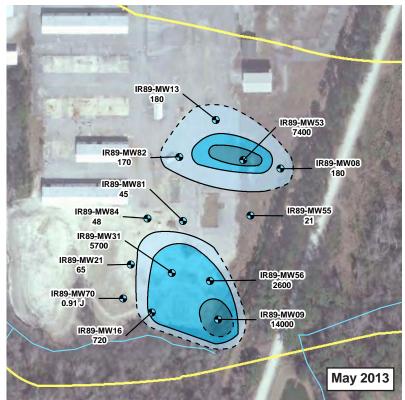
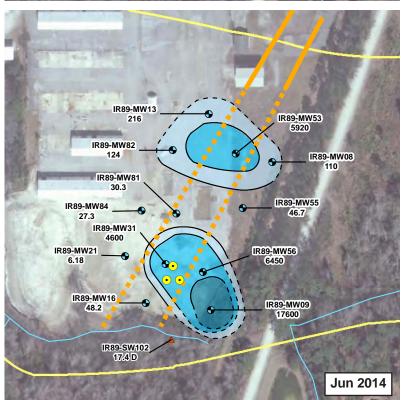
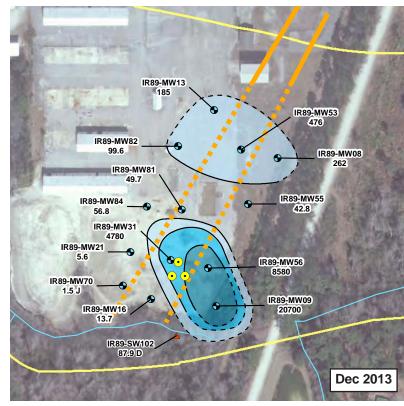


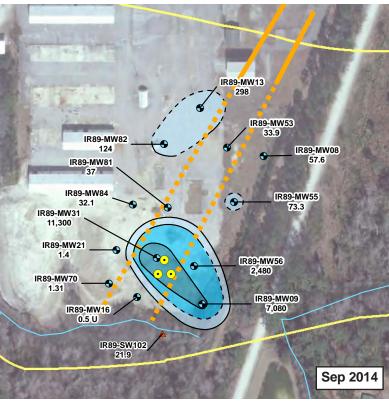
Figure 15-7 Site 89 Approximate Extent of TCE Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina

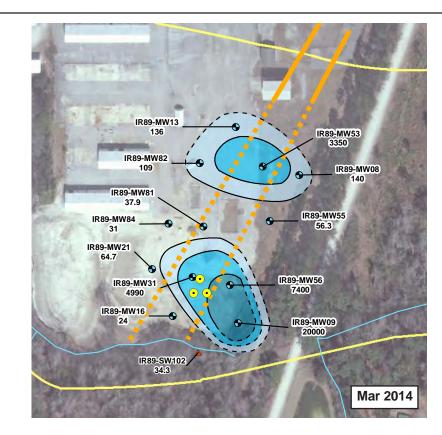












Monitoring Well

▲ Surface Water Sample

Vertical Sparging Points

Horizontal Air Sparging Wells (dash representing screen interval)

Stream

Site 89 Boundary

cis-1,2-DCE Extent (dashed where inferred)

70 μg/L - 700 μg/L

70 μg/L - 7,000 μg/L

7,000 μg/L - 70,000 μg/L

Notes:

DCE - Dichloroethene

1,2-cis-DCE NCGWQS - 70 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentrations is estimated

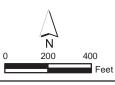
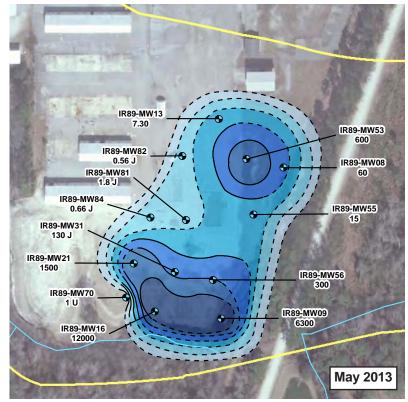
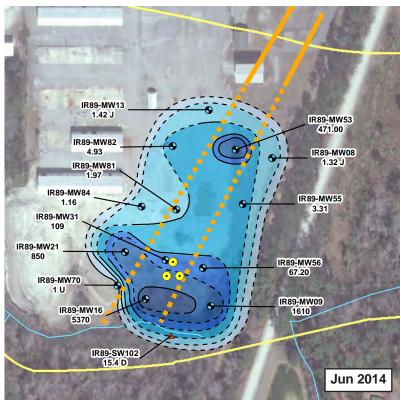
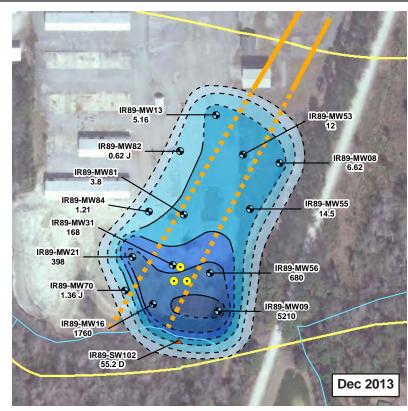


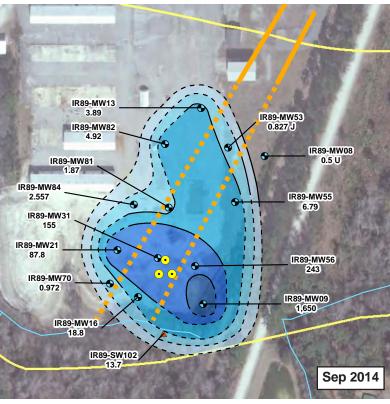
Figure 15-8 Site 89 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina

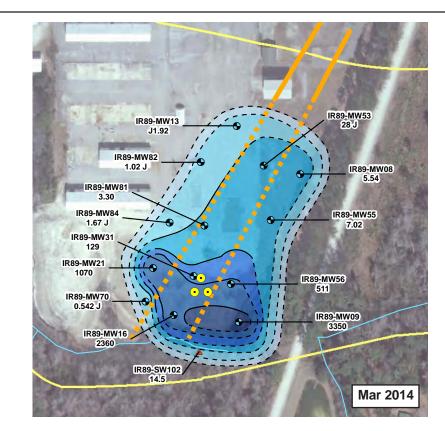












Monitoring Well

Surface Water Sample

Vertical Sparging Points

Horizontal Air Sparging Wells (dash representing screen interval)

Stream

Site 89 Boundary

VC Extents (dashed where inferred)

0.03 μg/L - 0.3 μg/L

0.3 μg/L - 3 μg/L

3 μg/L - 30 μg/L 30 μg/L - 300 μg/L

300 μg/L - 3,000 μg/L

3,000 μg/L - 30,000 μg/L

Notes:

VC - Vinyl Chloride
VC NCGWQS - 0.03 μg/L (April 2014)
NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentrations is estimated

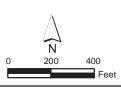
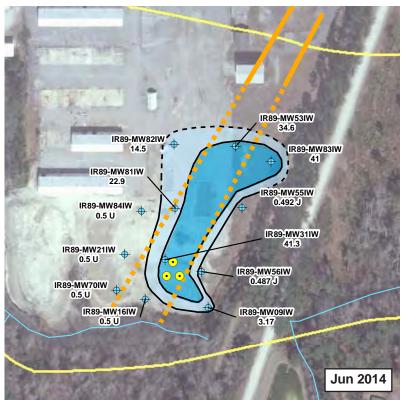
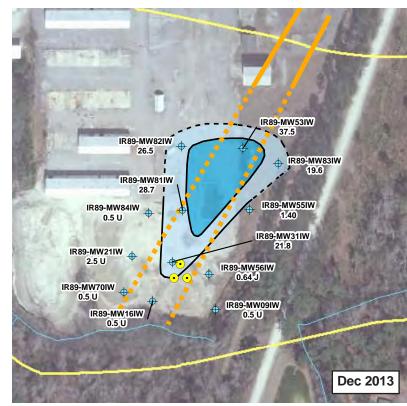


Figure 15-9 Approximate Extent of VC Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina

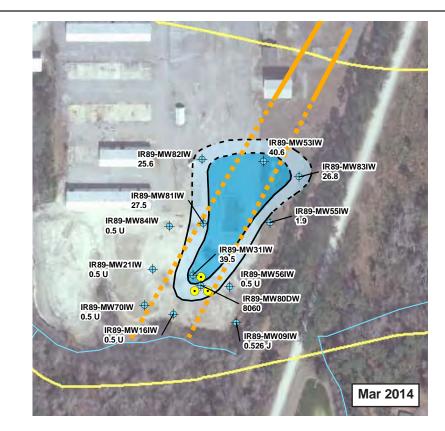












Monitoring Well

• Vertical Sparging Points

- Stream

Horizontal Air Sparging Wells (dash representing screen interval)

Site 89 Boundary

TCE Extent (dashed where inferred)

3 μg/L - 30 μg/L 30 μg/L - 300 μg/L TCE - Trichloroethene
TCE NCGWQS - 3 μg/L (April 2014)

Notes:

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

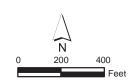
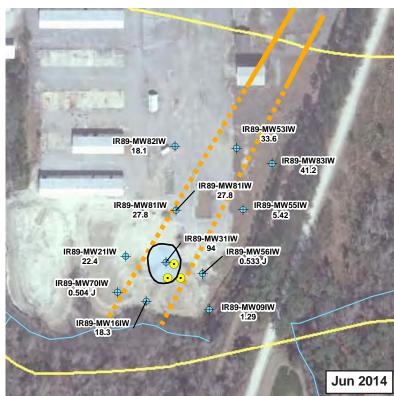
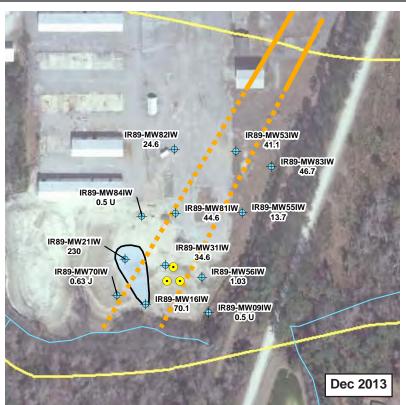


Figure 15-10
Site 89
Approximate Extent of TCE
Exceedances in the UCH Aquifer
2015 Five-Year Review
Camp Lejeune
North Carolina

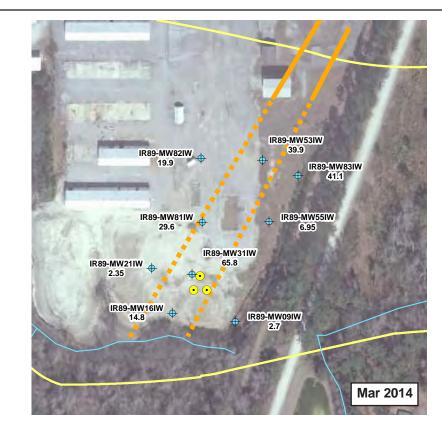












Monitoring Well

Vertical Sparging Points

Horizontal Air Sparging Wells (dash representing screen interval)

Stream

Site 89 Boundary

cis-1,2-DCE Extent (dashed where inferred)

70 μg/L - 700 μg/L

DCE - Dichloroethene

Notes:

1,2-cis-DCE NCGWQS - 70 μg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

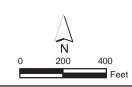
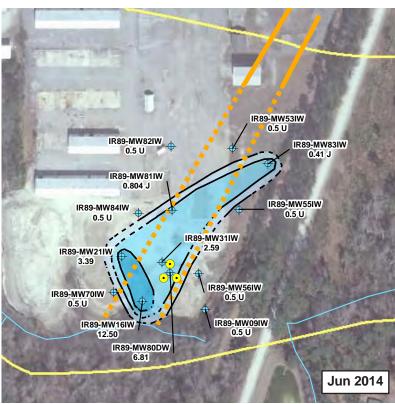
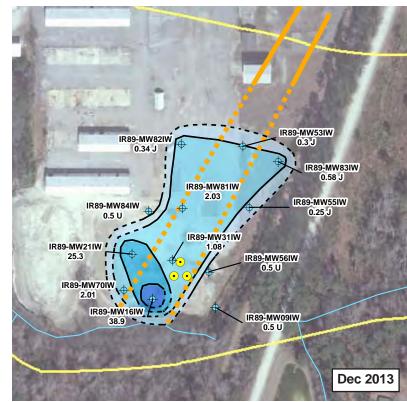


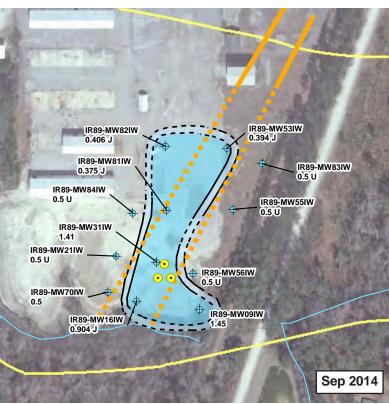
Figure 15-11
Site 89
Approximate Extent of 1,2-cis-DCE
Exceedances in the UCH Aquifer
2015 Five-Year Review
Camp Lejeune
North Carolina

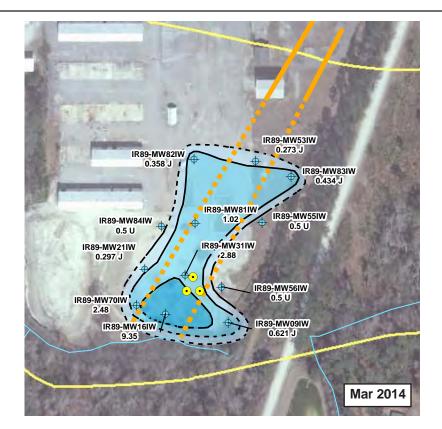












Monitoring Well Vertical Sparging Points Stream

Horizontal Air Sparging Wells

(dash representing screen interval) 30 μg/L - 300 μg/L Site 89 Boundary

VC Extents (dashed where inferred)

0.03 μg/L - 0.3 μg/L 0.3 μg/L - 3 μg/L 3 μg/L - 30 μg/L

VC - Vinyl Chloride VC NCGWQS - 0.03 ug/L (April 2014) NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter U - analyte not detected above detection limit J - concentration is estimated

Notes:

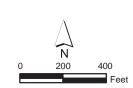
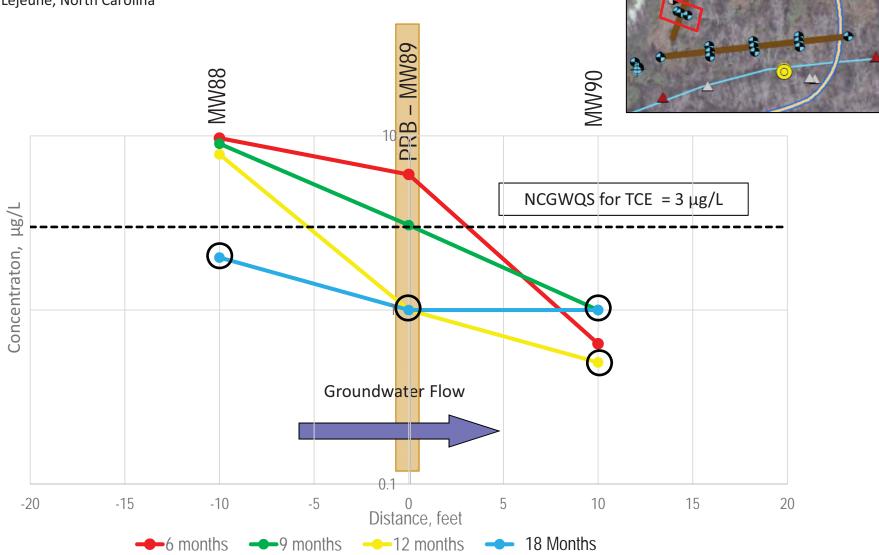


Figure 15-12 Approximate Extent of VC Exceedances in the UCH Aquifer 2015 Five-Year Review Camp Lejeune North Carolina



Figure 15-13
TCE Concentrations in IR89-MW89 Cluster
2015 Five-Year Review
Camp Lejeune, North Carolina



O Denotes a Non-Detect Result

Figure 15-14 VC Concentrations in IR89-MW89 Cluster 2015 Five-Year Review Camp Lejeune, North Carolina MW88 **MW90** 1000 100 Concentraton, µg/L 10 **Groundwater Flow** 0.1 NCGWQS for VC = $0.03 \mu g/L$ 0.01 -20 -15 -10 -5 5 10 15 20 0 Distance, feet →9 months → 12 months → 18 Months **─**6 months



Figure 15-15 TCE Concentrations in IR89-MW93 Cluster 2015 Five-Year Review Camp Lejeune, North Carolina NCGWQS for TCE = $3 \mu g/L$ **MW94** NCSWQS for TCE = $30 \mu g/L$ 100 KM **Groundwater Flow Edwards Creek** Concentraton, µg/l 10 NCGWQS for TCE = $3 \mu g/L$

-20

-10

Denotes a Non-Detect Result

0

10

20

30

Distance, feet

40

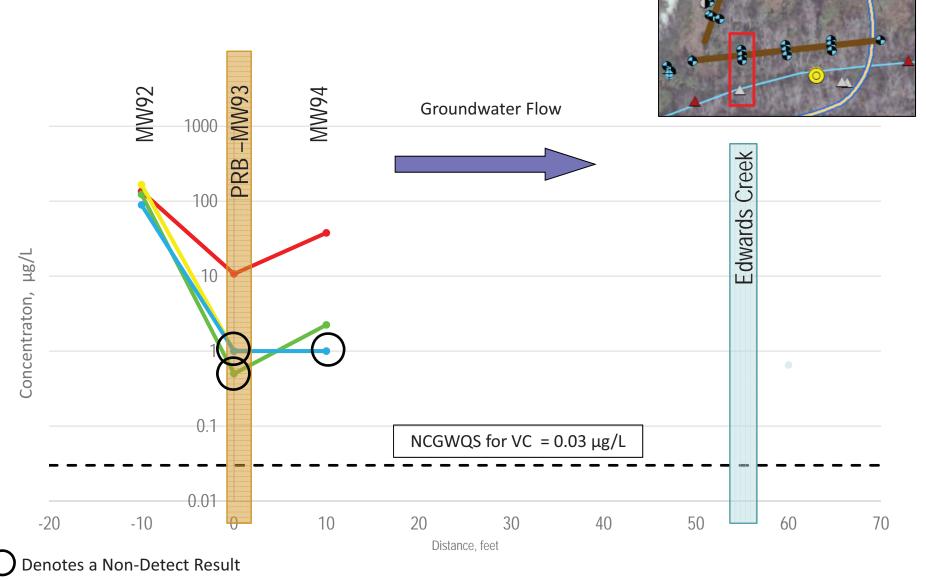
←6 months ←9 months ←12 months ← 18 Months

50

60

70

Figure 15-16 VC Concentrations in IR89-MW93 Cluster 2015 Five-Year Review Camp Lejeune, North Carolina



←6 months ←9 months ←12 months ← 18 Months

Figure 15-17
ORP Trends: In-wall Performance Monitoring Wells
2015 Five-Year Review
Camp Lejeune, North Carolina

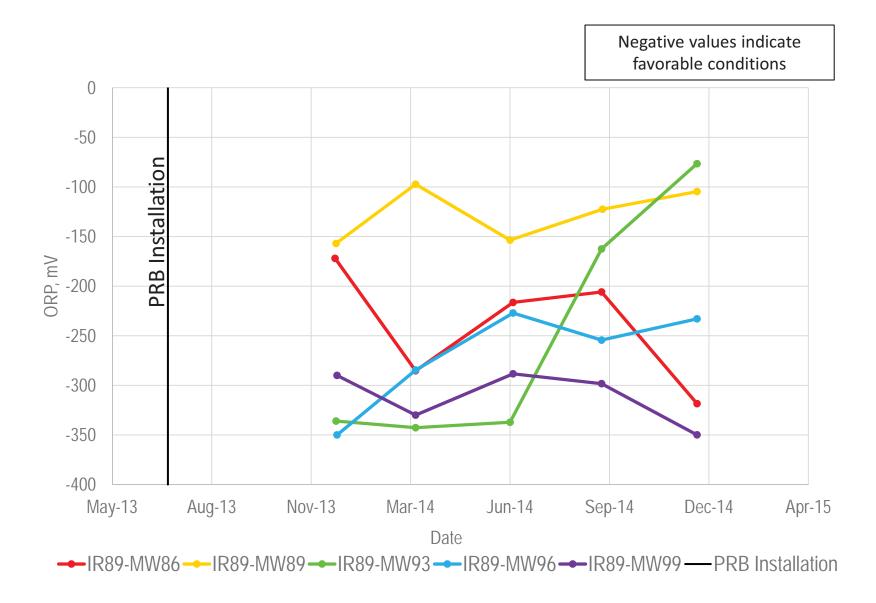
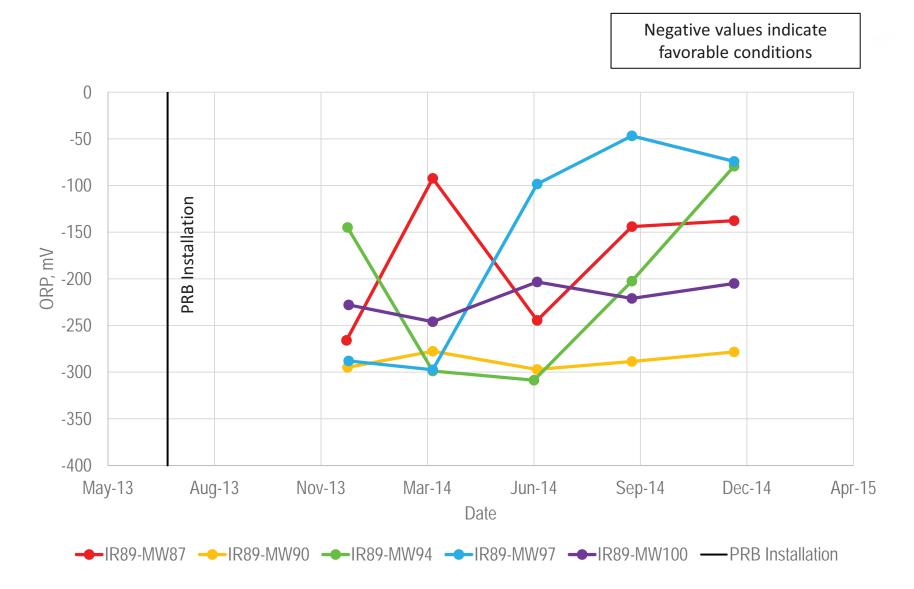
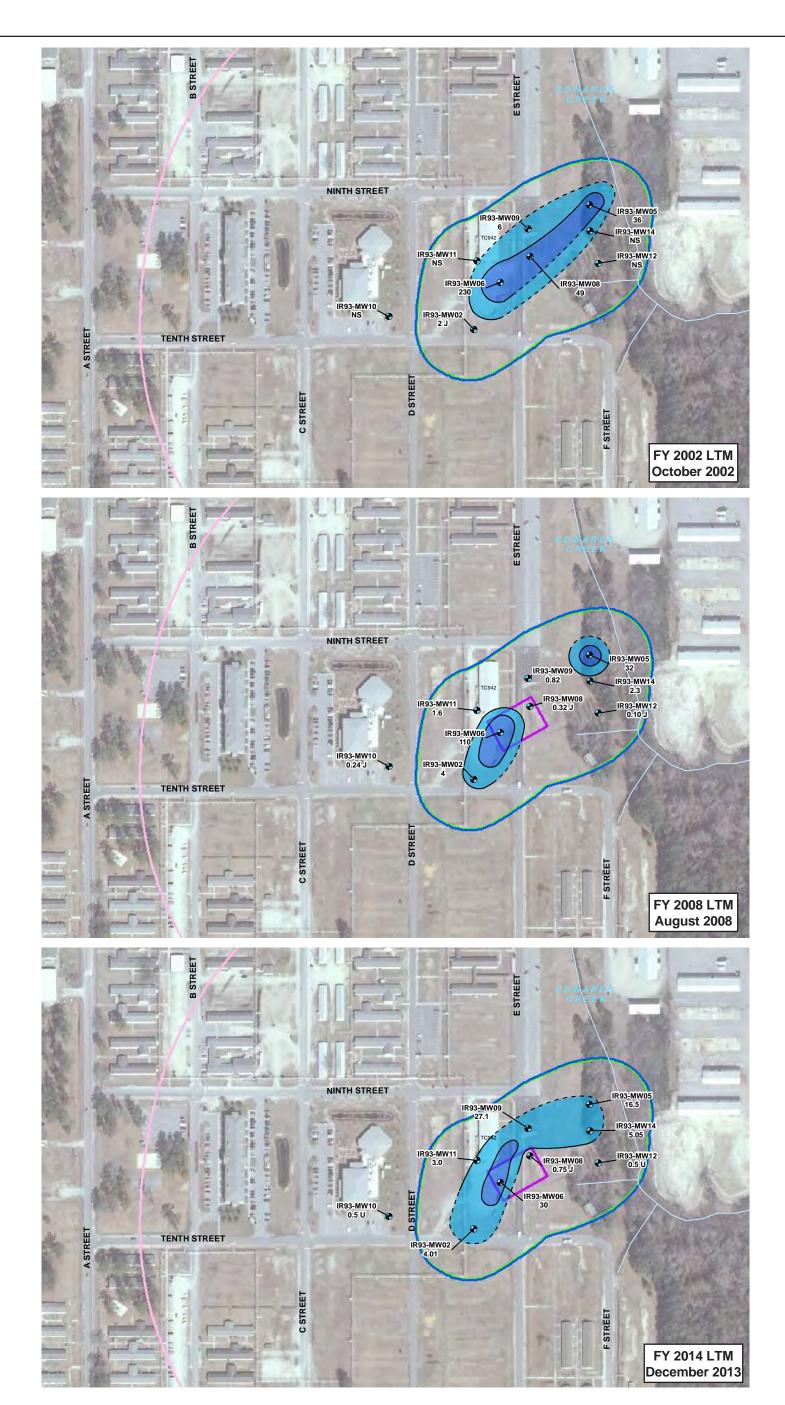


Figure 15-18

ORP Trends: Downgradient Performance Monitoring Wells
2015 Five-Year Review

Camp Lejeune, North Carolina







TCE Extent (dashed where inferred) Land Use Control Boundaries

3 μg/L - 30 μg/L 30 μg/L - 300 μg/L

Surface Water Centerline

Permanganate Treatment Area

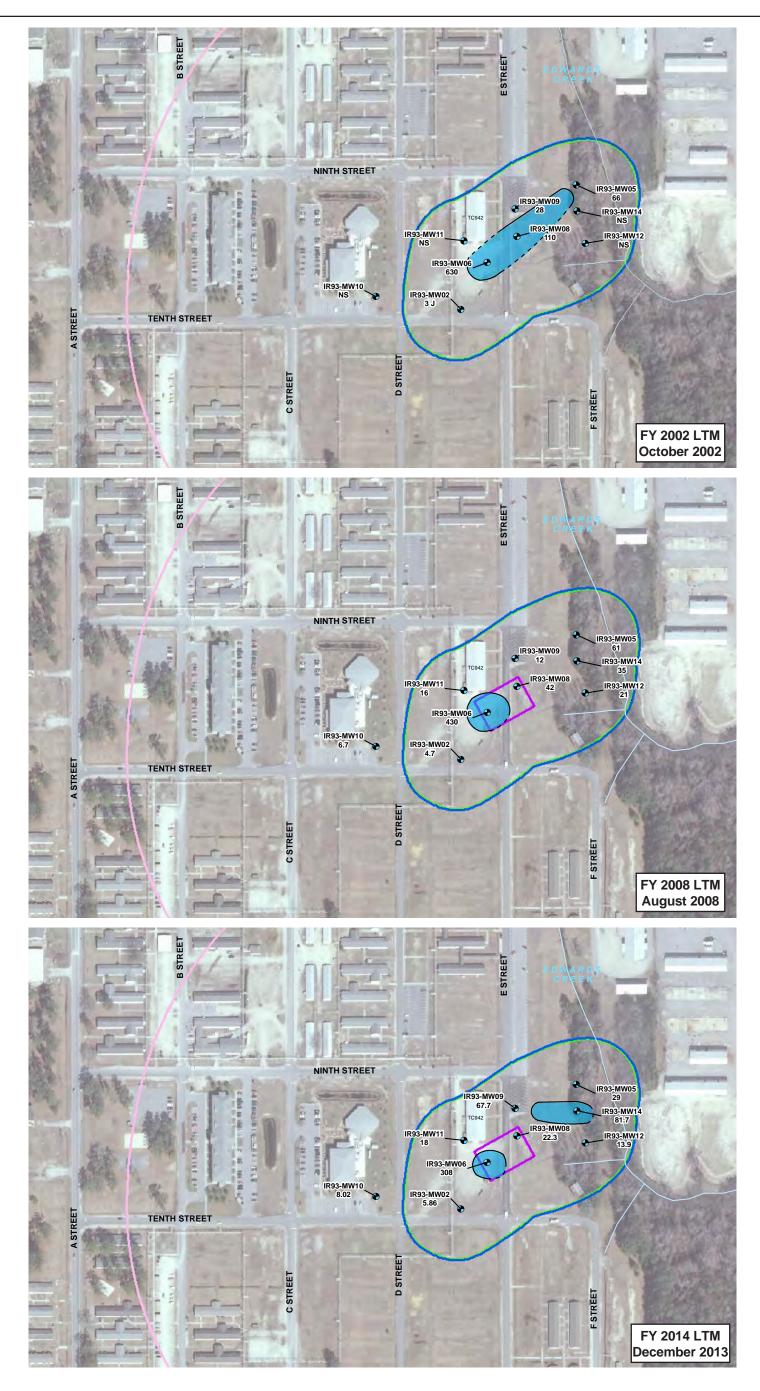
Aquifer Use Control Boundary
Intrusive Activities Control Boundary (Groundwater)
Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

1 inch = 250 feet

Notes:
TCE - Trichloroethene
TCE NCGWQS - 3 µg/L (April 2014)
NCGWQS - North Carolina Groundwater Quality Standard
µg/L - micrograms per liter

U - analyte not detected above detection limit J - concentration is estimated NS - not sampled

Figure 15-19 Site 93
Approximate Extent of TCE Exceedances
in the Surficial Aquifer
2015 Five-Year Review Camp Lejeune North Carolina CH2MHILL





Monitoring Well

Surficial Aquifer

Surface Water Centerline

Land Use Control Boundaries
Aquifer Use Control Boundary

Intrusive Activities Control Boundary (Groundwater)

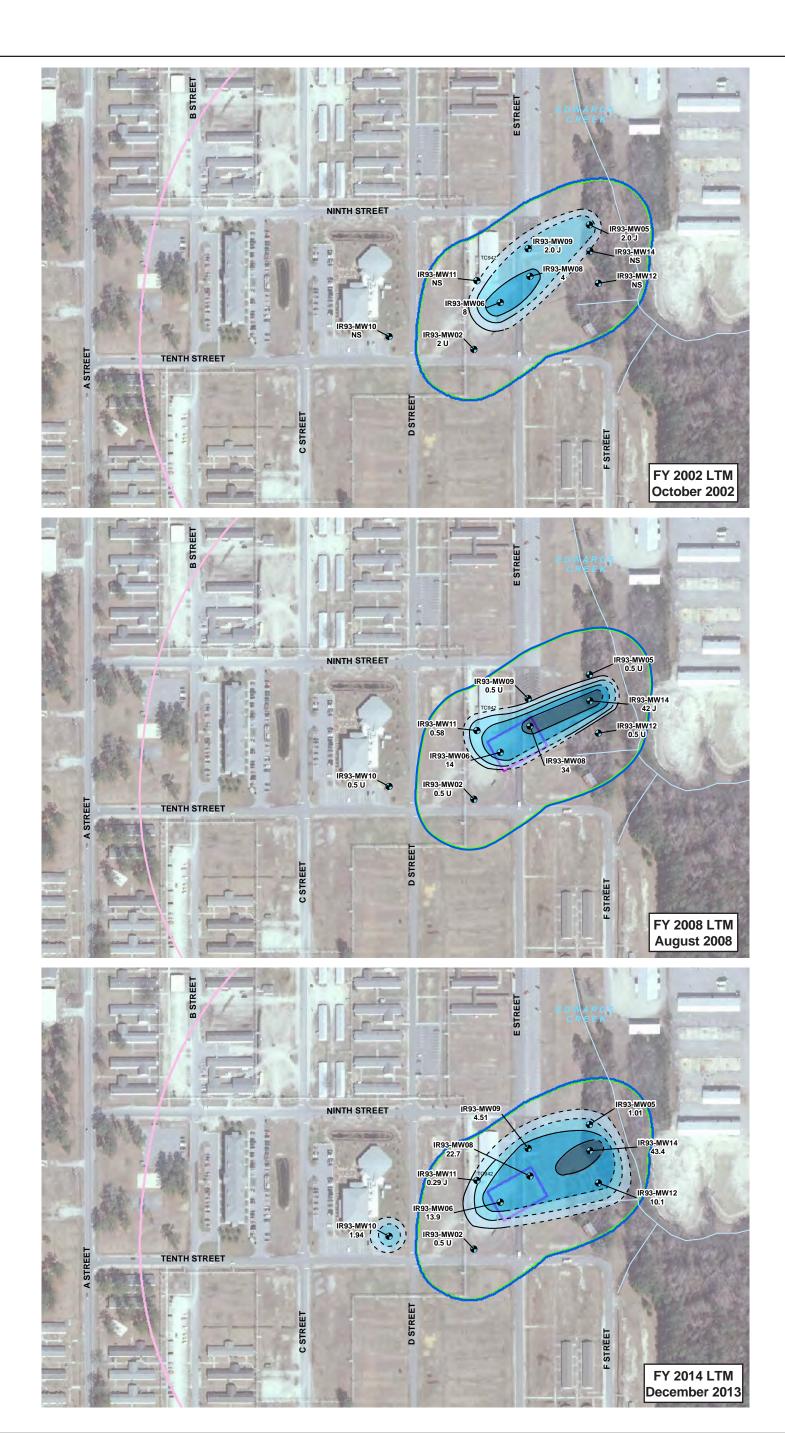
Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N 0 125 250 Fee 1 inch = 250 feet

Notes:
DCE - Dichloroethene
cis-1,2-DCE NCGWQS - 70 µg/L (April 2014)
NCGWQS - North Carolina Groundwater Quality Standard
µg/L - micrograms per liter
U - analyte not detected above detection limit
J - concentration is estimated
NS - not sampled

Figure 15-20 Site 93 Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina





Legend Monitoring Well

Surficial Aquifer

Surface Water Centerline Permanganate Treatment Area

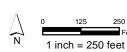
VC Extent (dashed where inferred)

0.03 μg/L - 0.3 μg/L 0.3 μg/L - 3 μg/L 3 μg/L - 30 μg/L 30 μg/L - 300 μg/L

Land Use Control Boundaries

Aquifer Use Control Boundary

Intrusive Activities Control Boundary (Groundwater)
Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)



Notes:

VC - Vinyl Chloride

VC NCGWQS - 0.03 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard
µg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

NS - not sampled

Figure 15-21 Site 93 Approximate Extent of VC
Exceedances in the Surficial Aquifer
2015 Five-Year Review Camp Lejeune North Carolina



Operable Unit 19 (Site 84)

16.1 Site History and Background

OU 19 is within Mainside (Figure 1-2) and consists of Site 84.

Site 84 — Former Building 45 covers approximately 5 acres just south of State Route 24, one mile west of the Main Gate (Figure 16-1). The property was purchased by the federal government in 1941 and Building 45 was a former electric substation, where transformers reportedly containing PCBs were used and possibly stored. The building was constructed by the Navy soon after purchasing the property, and leased to Tidewater Electric, who operated the building through 1965. In 1965, Building 45 was converted to a maintenance facility for large machinery. While no official operational history exists for the building and the surrounding property, former employees recalled that site activities included PCB transformer maintenance, recycling, and onsite disposal of spent transformer casings. A transformer was discovered near a wooded area and additional transformers (approximately 20), potentially containing PCB dielectric oil, were discovered near the woods of the powerhouse. Maintenance personnel at Building 45 have previously indicated that additional transformers may still be buried in areas near a former lagoon; however, an excavation is reported to have been performed by Public Works

 UST Investigation 1996 Corrective Action Plan Pre-RI Study UST Removal, Building 45 Demolition Concrete chip and surface water sampling 2001-2002 ·RI & FS •PRAP, EE/CA, Action Memorandum 2002 Phase I NTCRA (Soil) 2002-2004 Phase II NTCRA (Soil) 2005-2006 Supplemental Investigation 2006-2007 Phase III NTCRA (Soil) 2007 Closeout Report 2008 Amended FS & PRAP 2009 ·ROD 2010 •RIP (LUCs) and RACR Supplemental Assessment – AST45-S781

Center personnel and no waste materials were discovered.

16.2 Site Characterization

The findings from various investigations at OU 19 that are pertinent to the FYR are summarized in this section.

16.2.1 Physical Characteristics

- Surface Features The ground surface at Site 84 is generally flat. The northeast edge of the site runs along a pedestrian pathway and the northwest edge is bordered by Northeast Creek. The site is primarily wooded to the east and wetland areas are present adjacent to the creek.
- **Geology and Hydrogeology** Subsurface conditions generally consist of Coastal Plain deposits consisting of layers of sand, silt, and clay. It has been reported that a fine-grained, low-permeability layer exists between the surficial aquifer (2 to 40 feet bgs) and the UCH aquifer (greater than 40 feet bgs). Groundwater in the surficial aquifer flows toward Northeast Creek (Baker, 2002).

16.2.2 Land Use

Current Land Use – Current land use is classified as low occupancy industrial. A portion of the site is currently
part of a leased utility corridor and a photovoltaic farm was installed within the OU boundary.

ES120414012346RAL 16-1

Future Land Use – There are no anticipated changes in land use. However, when the utility corridor lease
agreements are scheduled for renewal in 2026, the companies with utilities within the PCB AOC, where
intrusive or access controls are required, will be notified of the contaminated area and given the option to
either properly excavate and dispose of PCB-contaminated soil and PCB waste soil or relocate their utilities
outside of the PCB AOC.

16.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details are located in the RI (Baker, 2002) and ROD (Rhēa, 2008).

- VOCs (primarily benzene and ethylbenzene), PAHs, pesticides, PCBs, and metals were detected in soils at OU 19. PCBs were widespread at low concentrations (1 to 10 mg/kg) with three "hot spots" that were identified during the RI. VOCs, pesticides, and metals were also detected in surficial groundwater.
- An HHRA and ERA were completed as part of the RI and included a pre-NTCRA scenario using all samples collected during the RI and a post-NTCRA scenario that used a sample set removing samples that were within the boundaries of proposed removal areas. The pre-NTCRA HHRA concluded that potential unacceptable risks to current adult recreational users and military personnel, future residents, construction workers, and industrial and commercial site workers were present from exposure to PAHs, pesticides, and PCBs in soil. The post-NTCRA HHRA concluded that potential unacceptable risks to residential receptors were present from PCBs in soil. Potential unacceptable risks were also present for future residents primarily from pesticides and metals in surficial aquifer groundwater.

The pre-NTCRA ERA concluded that PAHs, pesticides, PCBs, and metals in soil and VOCs, SVOCs, and PCBs in lagoon sediments may pose unacceptable risks to ecological receptors. While an NTCRA would reduce risks to ecological receptors, there were potential unacceptable risks remaining from Aroclor-1260 outside of NTCRA areas.

16.2.4 Interim Removal Actions

After completion of the HHRA and ERA but before the completion of the ROD, three NTCRAs were conducted to remove PCB-contaminated soil and a soil cover was put in place across the site. The NTCRAs are summarized as follows:

- Phase I (2002) was completed to remove the remaining building foundation at Building 45 and some surrounding PCB-contaminated soil. 4,857 tons of non-hazardous PCB-contaminated soil and 142 tons of petroleum-contaminated soil were removed from the site.
- Phase II (2002-2006) was completed to remove contaminated soil and lagoon sediments. Approximately 12,000 tons of contaminated soil/sediment were removed from the site. However, remediation goals were not met because the Phase II NTCRA uncovered additional areas of contamination.
- Phase III (2006-2007) was completed to remove additional PCB-contaminated soil to the south and west of
 the previous NTCRA locations. Complete excavation was deemed impractical in areas with buried, active
 utility, and communication lines. In these areas, a 2-foot-thick vegetative soil cover was placed over the PCBcontaminated soil.

Following the NTCRAs, the only remaining risk in groundwater was pesticides and supplemental groundwater sampling indicated pesticide levels were below NCGWQS, and groundwater at Site 84 was not considered a medium of concern (Rhēa, 2008).

16-2 ES120414012346RAL

16.3 Remedial Action Objectives

The ROD addressing soil at OU 19 was signed in January 2009 (Rhēa, 2009). The RAO identified for OU 19 is:

 Remove contaminated surface and subsurface soils that contain PCBs in excess of the selected remediation goal (i.e., cleanup level) and prevent exposure to remaining PCB-contaminated soil consistent with the requirements for a low occupancy industrial area.

The cleanup levels for OU 19 are presented in **Table 16-1**.

16.4 Remedial Actions

The OU 19 RA components and expected outcomes are summarized in **Table 16-2**. The RA for OU 19 includes the following major components:

- Removal of PCB-contaminated soil (completed via NTCRA, Section 16.2.4)
- LUC implementation for soil as follows:
 - Prohibit non-industrial land use which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.
 - Restrict intrusive activities within the areas of PCB contamination greater than 10 mg/kg in subsurface soils (i.e., greater than 2-foot depth).
 - Maintain the integrity of the 24-inch vegetative soil cover to limit exposure to subsurface soil with PCB contamination greater than 10 mg/kg.

16.4.1 Remedy Implementation

LUCs were implemented in 2009. The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

16.4.2 Remedy Operation and Maintenance

Currently, a fence and signs restrict access within the areas of PCB contamination greater than 10 mg/kg in subsurface soils. The LUCs are shown on **Figure 16-1** and summarized in **Table 16-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate the LUCs and general site conditions (**Appendix B**). One intrusion was reported in October 2012 during the LUC inspections when tire ruts deeper than 6 inches, but less than 24 inches, were observed in the roadway within the intrusive activities control boundary. A subsequent inspection noted that the ruts were naturally corrected and repairs were not needed.

TABLE 16-3
OU 19 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Non-Industrial Use Control Boundary (Soil)	4.6	Mary 2000	
Intrusive Activities Control Boundary (Soil)	0.55	May 2009	March 2010
Access Control Boundary	0.14		

16.4.3 Progress Since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in Table 16-4.

ES120414012346RAL 16-3

TABLE 16-4 2010 FYR OU 19 Recommendations/Follow-up Actions

Issues Recommendations / Follow-up Actions		Date Completed/Current Status	
Monitoring wells remain in place	Abandon existing monitoring wells in accordance with NC Regulations. (2012)	Completed in 2012. Monitoring wells were abandoned at Site 84.	

In addition to these follow-up actions, a RACR was completed to document the final remedy at Site 84 (Rhēa, 2010).

16.5 Technical Assessment

Is the remedy functioning as designed?

Yes. LUCs have been implemented to prohibit non-industrial land use and restrict intrusive activities. A fence and signs also restrict access.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time the final ROD was signed are still valid (**Table 16-1**).

Changes in Exposure Pathways: No changes in exposure pathways were identified that would impact the protectiveness of the remedy at OU 19.

Changes in Toxicity and Other Contaminant Characteristics: The final ROD was signed in 2009 and there have been no changes in toxicity values, regulatory levels, and risk characteristics of COCs at OU 19. Although there have been some changes to toxicity criteria for other chemicals detected at the site that were not identified as COCs (Table 2-1), these changes would not affect the protectiveness of the remedy, as LUCs prevent exposure to site media and limit site use.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

16.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 19 during this FYR.

16.7 Statement of Protectiveness

The remedy for soil at OU 19 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit soil intrusive activities and prohibit non-industrial use within the extent of the former soil removal action areas where PCBs remain in soil above levels that allow for UU/UE. A fence and signs were also installed to restrict access within the areas of PCB contamination greater than 10 mg/kg in subsurface soils.

16.8 References

Baker. 2002. Remedial Investigation, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, North Carolina. May.

Rhēa. 2008. Feasibility Study Amendment, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, North Carolina. May.

Rhēa. 2009. Record of Decision, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. September.

Rhēa. 2010. Remedial Action Completion Report, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.

16-4 ES120414012346RAL

TABLE 16-1

Cleanup Levels for OU 19 (Site 84)

2015 Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels for Intrusive Activities (RHEA, 2009)	Cleanup Level Reference	ROD Cleanup Levels for Industrial Land Use (RHEA, 2009)	Cleanup Level Reference
Soil (mg/kg)	PCBs	10	Action Level for Low Occupancy Land Use (USEPA, 1990)	1	Action Level for High Occupancy Land Use (USEPA & TSCA)

Notes:

Shading indicates cleanup levels achieved/remedy protective (Rhēa, 2010)

TABLE 16-2

OU 19 Remedial Action Summary and Expected Outcomes

2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
84		Potential exposure to residents and	Utilities ¹ /	Remove contaminated surface and subsurface soils that contain PCBs in excess of the selected remediation goal (i.e., cleanup level) and prevent exposure to	Soil Removal	Excavation and offsite disposal of PCB-contaminated soil from areas of concern to meet industrial levels.	Utilities/
64		industrial workers to PCBs in soil.	vacant	remaining PCB contaminated soil consistent with the requirements for a low occupancy industrial area.		Maintain non-industrial use, intrusive activities, and access controls and monitor quarterly.	Use

Notes

¹ When the utility corridor lease agreements are scheduled for renewal in 2026, the companies with utilities within the PCB AOC, where intrusive or access controls are required, will be notified of the contaminated area and given the option to either properly excavate and dispose of PCB-contaminated soil and PCB waste soil or relocate their utilities outside of the PCB AOC.



Operable Unit 20 (Site 86)

17.1 Site History and Background

OU 20 is within the operations area of MCAS New River (Figure 1-2) and consists of Site 86.

Site 86 — Tank Area AS419-AS421 is

approximately 146 acres (**Figure 17-1**). From 1954 to 1988, Site 86 served as a storage area for petroleum products. In 1954, three 25,000-gallon ASTs were installed within an earthen berm. The three tanks were reportedly used for No. 6 fuel oil storage until 1979. From 1979 to 1988, the tanks were used for temporary storage of waste oil. The three tanks were emptied in 1988 and were removed in 1992. In 2006, the site boundary was expanded to include SWMU 303/318 (located south of Site 86) based on CVOCs detected in groundwater from the former Helicopter Wash Pad.

17.2 Site Characterization

The findings from various investigations at OU 20 that are pertinent to the FYR are summarized in this section. Details regarding the CSM are located

1990 Preliminary Site Investigation 1992 UST Assessment 1995-1996 1997-2000 Post-RI Fieldwork 1998-2005 Groundwater LTM Amended RI 2004- Pilot Study (Air/Ozone Sparging) 2007-2011 ·ESRI ·Pilot Study (ERD) 2012 2012-·Feasibility Study •PRAP and ROD 2014

in the Expanded Supplemental Remedial Investigation (ESRI) (CH2M HILL, 2011a) and the ROD (CH2M HILL, 2014).

17.2.1 Physical Characteristics

- Surface Features Site 86 is located on an active military flight line with multiple areas of limited or restricted access. Approximately half of the site is developed with buildings, parking lots, landscaped areas, and the flight line. Storm water runoff from the western portion of the site flows east through storm drains that discharge to a drainage ditch and ultimately to the New River. Storm water from the northern portion of the site flows to a retention pond.
- Geology and Hydrogeology Subsurface conditions generally consist of Coastal Plain deposits including silts, clays, fine sands, and limestone. Groundwater is typically encountered at depths ranging from approximately 3 to 10 feet bgs. In general, the groundwater flow direction within the surficial and Castle Hayne aquifers is to the east-northeast towards the New River. The surficial aquifer extends from the water table to a depth of approximately 25 feet bgs where the Castle Hayne confining unit is encountered at thicknesses of 20 to 40 feet (Baker, 1996).

17.2.2 Land Use

- Current Land Use The majority of Site 86 consists of the MCAS New River flight line and supporting operations.
- Future Land Use There are no anticipated changes in land use.

17.2.3 Site Characterization and Risk Assessment Results

This section presents a summary of the site characteristics and risks that led to the ROD. An RI was completed in 1996 (Baker, 1996); however, several IRAs were completed which changed site conditions and reduced risks. The site was re-evaluated during the ESRI and preparation for the FS (CH2M HILL, 2011 and 2013).

ES120414012346RAL 17-1

- Benzene, PCE, TCE, cis-1,2-DCE, and VC were detected in surficial and Castle Hayne aquifer groundwater at concentrations exceeding their respective screening levels.
- An HHRA and ERA were completed as part of the ESRI (CH2M HILL, 2011) and revisited during the FS
 (CH2M HILL, 2013). Potential unacceptable human health risks were identified for future industrial workers or
 residents from exposure to PCE, TCE, and VC in groundwater from the surficial, UCH, and MCH aquifers. There
 were no unacceptable ecological risks identified.

17.2.4 Interim Removal Actions

Several pilot studies and a removal action have been implemented to reduce COC mass in the areas with the highest historical concentrations identified during the RI (Baker, 1996) and the ESRI (CH2M HILL, 2011a).

- A removal action that consisted of excavating and offsite disposal of approximately 1,200 tons of SVOC and metals-impacted soil was completed in 2005. Confirmatory samples indicated all target contaminants were below screening levels.
- An AS/ozone injection pilot study was conducted from 2005 to 2006. Ozone was injected via an HDD well installed in an area with elevated TCE concentrations in groundwater (28 μg/L to 1200 μg/L). The well was 950 feet long with 350 feet of screen at approximately 60 feet bgs. The pilot study system reduced concentrations of TCE by approximately 99 percent in the target treatment area (AGVIQ and CH2M HILL Joint Venture, 2006).
- An ERD recirculation pilot study was completed from 2011 to 2012. The study consisted of injecting
 approximately 30,000 pounds of sodium lactate through a series of injection wells and extracting and reinjecting groundwater to distribute the sodium lactate and treat approximately 330,000 cubic feet of
 impacted aquifer. The study reduced concentrations of VOCs by approximately 80 percent near the eastern
 end of the industrial portion of Site 86 (CH2M HILL, 2013).
- An ISCO pilot study using slow-release permanganate candles was conducted from 2011 to 2012. The study
 consisted of placing 60 slow-release permanganate candles 27 to 33 ft bgs in 30 locations along two 80-ft long
 transects. Follow-up monitoring indicated initial VOC concentrations were reduced by 81 percent and
 subsequent monitoring results were variable (CH2M HILL, 2013).

These pilot studies and removal actions treated the highest concentrations of COCs, and, as a result, MNA was considered to be a viable option that could be achieved within a reasonable timeframe (CH2M HILL, 2013).

17.3 Remedial Action Objectives

The ROD addressing groundwater at OU 20 was signed in October 2014 (CH2M HILL, 2014). The RAOs identified for OU 20 are to:

- Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE.

The cleanup levels for OU 20 are presented in Table 17-1.

17.4 Remedial Actions

The OU 20 RA components and expected outcomes are summarized in **Table 17-2**. The RA for OU 20 includes the following major components:

- LTM of groundwater to monitor the effectiveness of MNA.
- LUC implementation for groundwater as follows:

17-2 ES120414012346RAL

- Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring,
 from the surficial and UCH aquifers within 1,000 feet of the estimated impacted groundwater extent.
- Require consideration of the VI pathway for any future construction within 100 feet of VOC-impacted groundwater.
- Maintain the integrity of any existing or future monitoring or remediation system at the site, such as groundwater monitoring wells.

17.4.1 Remedy Implementation

Long-term Monitoring and Land Use Controls

LTM will be initiated at Site 86 in 2015. The proposed LUCs will be filed with Onslow County as a Notice of Contaminated Site and will be included in Base Master Planning and GIS.

17.4.2 Remedy Operation and Maintenance

Long-term Monitoring

LTM will begin in 2015 and will include 27 surficial, 27 UCH, and one MCH aquifer monitoring wells. Groundwater samples will be collected and analyzed annually for VOCs and every five years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon).

Land Use Controls

The proposed LUCs are shown on **Figure 17-1** and summarized in **Table 17-3**. Monitoring of the LUCs will be performed quarterly by the Base. A visual inspection of the site was conducted in March 2014 to evaluate general site conditions (**Appendix B**). No items of note were observed during inspections.

TABLE 17-3
OU 20 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Industrial/Non-Industrial Use Control Boundary (VI)	97	Dranacad	
Aquifer Use Control Boundary (1,000 feet)	501	Proposed	

17.4.3 Progress Since the 2010 Five-Year Review

OU 20 was not included in the 2010 FYR. Since 2010, the ESRI, FS, and ROD were completed. Additionally, pilot tests were completed, as discussed in **Section 17.2.4**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 17-2**.

17.5 Technical Assessment

Is the remedy functioning as designed?

The remedy will be implemented in 2015. The next FYR will evaluate the remedy.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. All assumptions, data, cleanup levels, and RAOs used at the time of the ROD are still valid.

Has any other information come to light that could question the protectiveness of the remedy?

Sampling for emerging contaminant 1,4-dioxane has not been completed at the site and, although they were not considered COCs, multiple detections of indicator chemicals 1,1-DCA and 1,1-DCE in groundwater at Site 86 indicate that 1,4-dioxane may be present in site groundwater.

ES120414012346RAL 17-3

17.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 20 are summarized in Table 17-4.

TABLE 17-4
OU 20 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight Agency	Milestone	Affects Protectiveness (Y/N)	
		Kespolisible	Agency	Date -	Current	Future
An RSL was established for 1,4-dioxane and indicator constituents are present in groundwater.	Collect groundwater samples for 1,4-dioxane to evaluate presence/absence	Navy/Base	USEPA/State	9/30/2018	N	Y

17.7 Statement of Protectiveness

The remedy at OU 20 will be protective of human health and the environment when it is implemented because exposure pathways that could result in unacceptable risks will be controlled by LUCs preventing exposure to groundwater COCs. MNA to monitor the VOC plume and LUCs will be implemented in 2015 to prohibit non-industrial and aquifer use until cleanup levels are achieved. To facilitate protectiveness, Base Master Planning maintains all current VOC plume data in the GIS and all construction projects go through environmental review.

17.8 References

AGVIQ and CH2M HILL Joint Venture. 2006. *Pilot Study Report, Site 86, Operable Unit No. 20, Marine Corps Base Camp Lejeune, North Carolina*. September.

Baker. 1996. Remedial Investigation Report, Operable Unit No. 20 (Site 86), Marine Corps Base Camp Lejeune, North Carolina. August.

CH2M HILL. 2011a. Expanded Supplemental Remedial Investigation, Site 86-Operable Unit No. 20, Marine Corps Base, Camp Lejeune, North Carolina. February.

CH2M HILL. 2013. Feasibility Study, Site 86 Operable Unit No. 20 Marine Corps Installations East – Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. October.

CH2M HILL. 2014. Record of Decision Operable Unit No. 20 Site 86 Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. October.

17-4 ES120414012346RAL

TABLE 17-1 Cleanup Levels for OU 20 (Site 86) 2015 Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	COCs ROD Cleanup Levels (CH2M HILL, 2014)		
	VOCs			
	Benzene	1	NCGWQS	
Croundwater (ug/L)	cis-1,2-Dichloroethene	70	NCGWQS/MCL	
Groundwater (μg/L)	Tetrachloroethene	0.7	NCGWQS	
	Trichloroethene	3	NCGWQS	
	Vinyl chloride	0.03	NCGWQS	

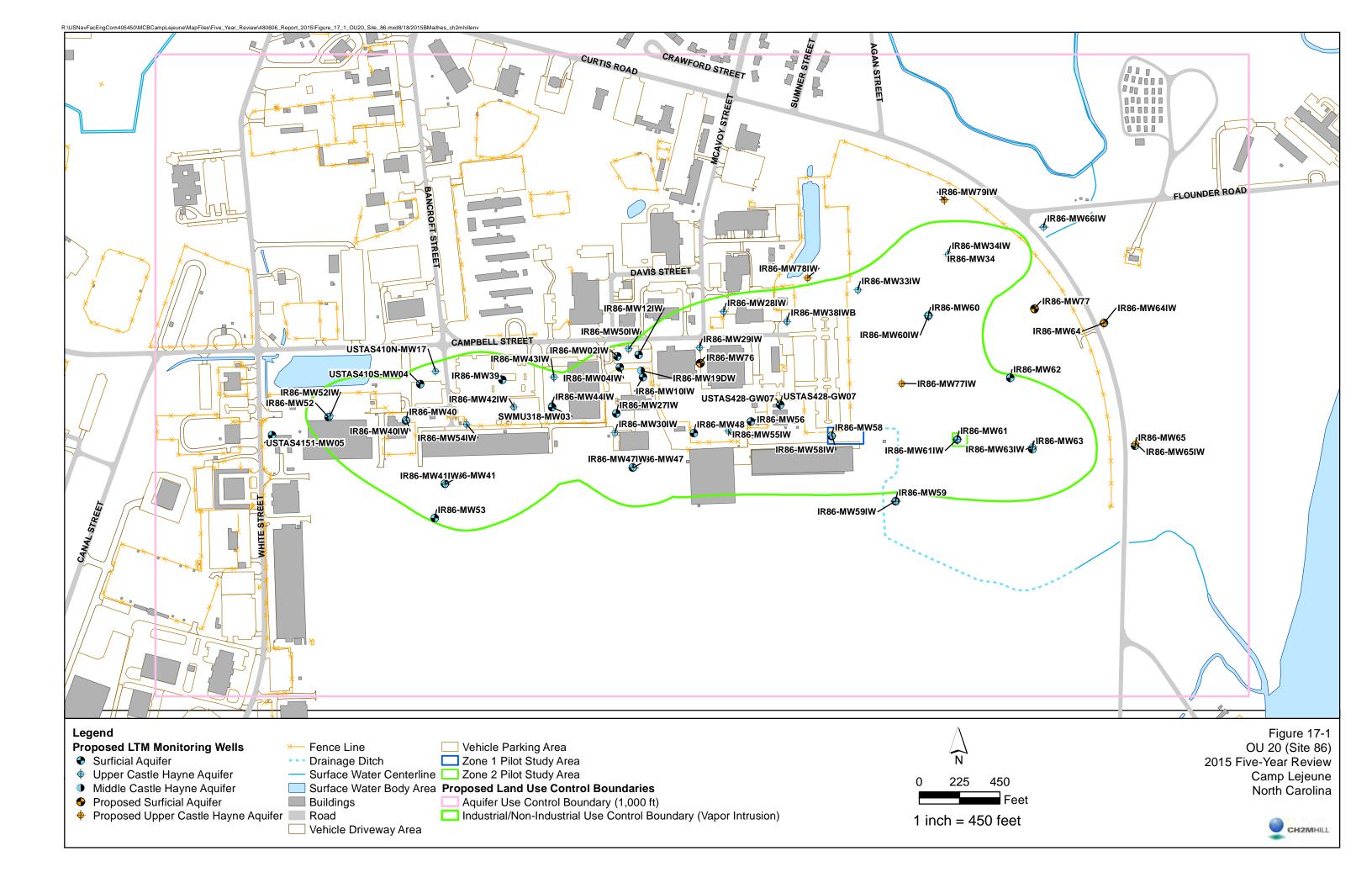
Cleanup Level Reference Dates:

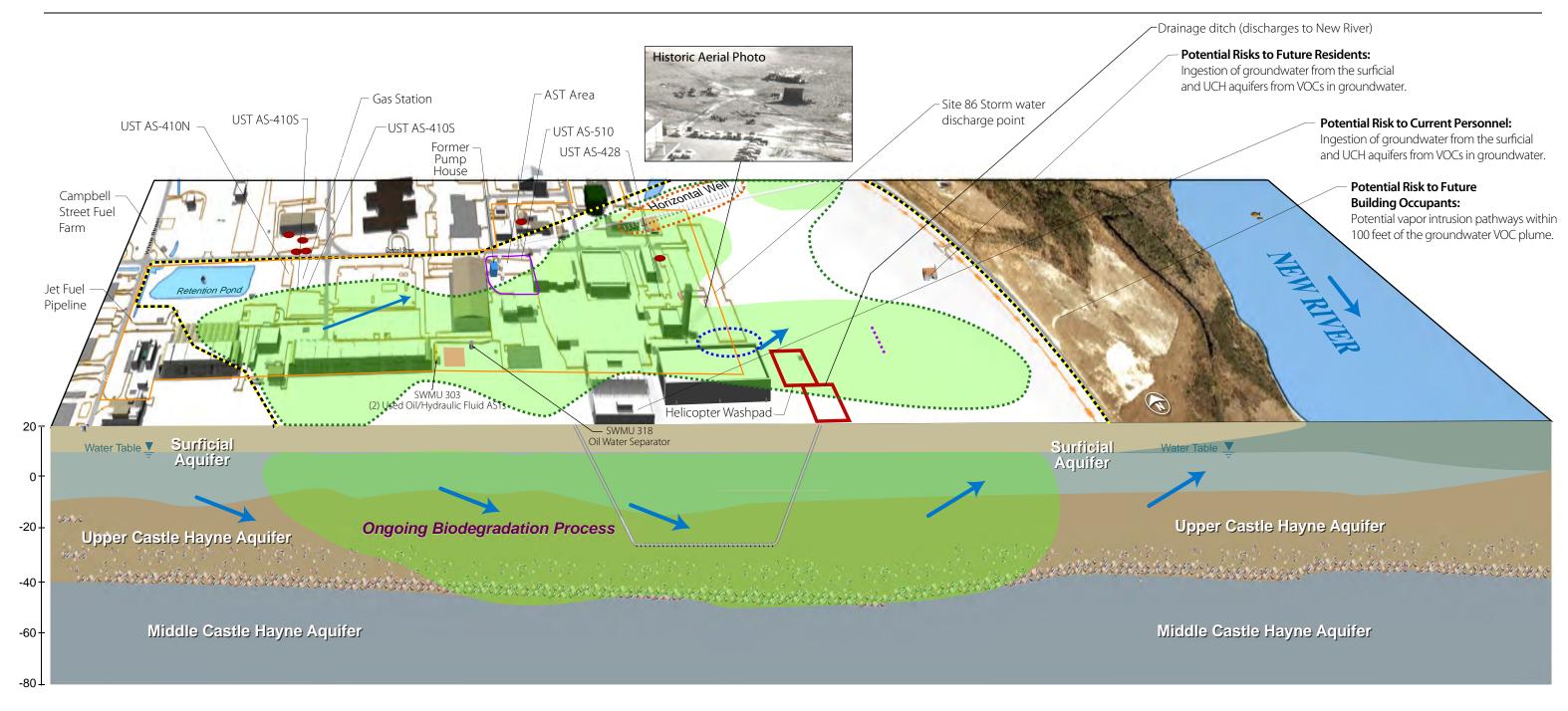
MCL (May 2009) NCGWQS (April 2013)

TABLE 17-2
OU 20 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/ Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
86		Potential unacceptable risks to future residents from		Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.	MNA	Implement groundwater MNA to monitor COC concentrations and migration until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	UU/UE
		exposure to VOCs in groundwater.		Prevent exposure to COCs in groundwater and vapor intrusion from COCs in groundwater until such time as groundwater concentrations or vapor intrusion mitigation measures allow for UU/UE.	LUCs	Maintain industrial/non-industrial use (VI) and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	





Checked by: T.Grim/CLT

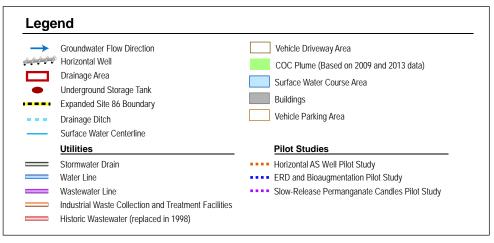


FIGURE 17-2 Site 86 Conceptual Site Model 2015 Five-Year Review Camp Lejeune North Carolina

Note: Not to scale.

Operable Unit 21 (Site 73)

18.1 Site History and Background

OU 21 is within the Courthouse Bay area on the Mainside of the Base (Figure 1-2) and consists of Site 73.

Site 73 — Amphibious Vehicle Maintenance Facility is approximately 14 acres, located along the northwest shore of Courthouse Bay, and was constructed in 1946 (Figure 18-1). This facility consists of numerous buildings, ASTs, USTs, vehicle wash racks, and OWSs. Active USTs and former UST locations are present within the fenced area surrounding Building A47 and in the vicinity of Buildings A1, A2, and A10. Several hazardous waste storage areas are located within Site 73, and were used to accumulate wastes generated by maintenance activities. Historical maintenance activities, dating from 1946 to 1977, reportedly resulted in spills or disposal of used motor oil and battery acid directly to the ground surface northeast of former Building A3.

18.2 Site Characterization

The findings from various investigations at OU 21 that are pertinent to the FYR are summarized in this section.

18.2.1 Physical Characteristics

Surface Features – OU 21 is primarily paved and contains maintenance and storage buildings.
 Ground surface elevation ranges from approximately 5 to 10 feet above mean sea level (amsl), with a gentle slope towards
 Courthouse Bay. There are two small unnamed tributaries to the east and west, and retention ponds to the west, all ultimately discharging to Courthouse Bay.

1983	•IAS			
1985	•Confirmation Study			
1991- 1993	•UST Investigations			
1994	Preliminary Investigation			
1997	•RI			
1998	•Supplemental Groundwater Investigation and FS			
1998	•Groundwater Modeling Report			
2000- 2005	•LTM			
2002	Natural Attenuation Evaluation Study			
2003	Technology Evaluation			
2003- 2006	Hydrogen Sparging Pilot Study			
2008	•Phase 2 Pilot Study	•Phase 2 Pilot Study		
2006- 2009	•Supplemental RI			
2009	•FS, PRAP, and ROD			
2009- Present	•LTM			
2007- 2011	Basewide VI Evaluation			
2009- 2011	•RIP and Interim RACR (AS, Biobarrier, LTM, LUCs)			
2012	•AS System Off - March			
2013	•Second Biobarrier Injection			

• **Geology and Hydrogeology** – Subsurface conditions generally consist of Coastal Plain deposits that include sands, silts, clays, and cemented sands (Baker, 1997). A laterally discontinuous semi-confining dense silty layer overlies the Castle Hayne aquifer. Where the semi-confining layer is absent, the surficial and Castle Hayne aquifers are in direct hydraulic communication. The water table is typically encountered at depths ranging from 1 to 12 feet bgs. In general, the groundwater flow direction within the surficial and Castle Hayne aquifers is to the south and southeast toward Courthouse Bay. The surficial aquifer in the area of Site 73 extends to a depth of approximately 25 feet bgs, where the UCH aquifer is encountered, which extends to approximately 90 feet bgs. The MCH aquifer is present from approximately 90 to 150 feet bgs.

ES120414012346RAL 18-1

18.2.2 Land Use

- Current Land Use Current land use consists of the Amphibious Vehicle Maintenance Facility and supporting
 operations.
- Future Land Use There are no anticipated changes in land use.

18.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. The most comprehensive site characterization took place during the original RI (Baker, 1997). Further characterization was completed as part of the SGI and FS (Baker, 1998), the Natural Attenuation Evaluation Study (CH2M HILL, 2002), and Supplemental RI (CH2M HILL, 2009a).

- VOCs (primarily CVOCs and BTEX compounds) were detected in surficial, UCH, and MCH aquifers.
 Groundwater and petroleum hydrocarbons were detected in soil at concentrations exceeding the cleanup levels.
- An HHRA and ERA were completed as part of the RI (Baker, 1997) and Supplemental RI (CH2M HILL, 2009a).
 Potential unacceptable human health risks were identified for future residents from exposure to CVOCs in groundwater, and PAH-fraction class C11-C22 in subsurface soil (inhalation/incidental exposure). The area of soil contamination is currently paved. No potential unacceptable ecological risks were identified.

18.2.4 Interim Removal Actions

After completion of the HHRA and ERA but before the completion of the ROD, the following pilot studies were completed at Site 73 to evaluate treatment technologies for full-scale implementation.

- From March 2004 through May 2005, a pilot study was conducted on the TCE "hot spot" located near building A47 to evaluate the effectiveness of hydrogen sparging for the remediation of dissolved-phase CVOCs. An HDD well, with a 400-foot long screen, was installed approximately 75 feet bgs. The stated goal of the pilot study was to achieve an order-of-magnitude reduction in dissolved phase TCE concentrations (MicroPact/Baker, 2006). The average TCE concentration decreased approximately 35 percent over the 15-month study period, while the average total VOC concentration decreased by approximately 8 percent.
- In 2007, a pilot study was initiated to evaluate the effectiveness of air and ozone sparging for removal of TCE and associated CVOCs from groundwater near the former maintenance Building A3, southeast of Building A47. The pilot test was performed using the existing HDD well. Assessment of ozone sparging proved inconclusive due to limited period of continuous ozone generation; however, TCE concentrations were reduced 75 percent in groundwater samples collected from monitoring wells with baseline concentrations exceeding 1,100 μg/L and the pilot study indicated that an HDD well is effective for distributing gas phase reagents at Site 73. Results of the groundwater sampling events indicated a combined effect of mass transfer (air stripping) with some degree of biodegradation (ERD) appears to have occurred during the course of the study period (AGVIQ/CH2M HILL, 2008).

18.3 Remedial Action Objectives

The ROD addressing groundwater and subsurface soil at OU 21 was signed in November 2009 (CH2M HILL, 2009c). The RAOs identified for OU 21 are:

- Restore groundwater quality at Site 73 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent human ingestion of water containing COCs (benzene, TCE, cis-1,2-DCE, 1,1-DCE, and VC) at concentrations above NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.
- Prevent future residential exposure to petroleum hydrocarbon-contaminated soils above the NC SSL and minimize transport to groundwater.

18-2 ES120414012346RAL

Minimize migration of COCs in groundwater to surface water.

The cleanup levels for OU 21 are presented in Table 18-1.

18.4 Remedial Actions

The OU 21 RA components and expected outcomes are summarized in **Table 18-2**. The RA for OU 21 includes the following major components:

- AS using the existing HDD well to address CVOCs via mass transfer and/or aerobic biological degradation.
- Substrate injections to create an ERD biobarrier to treat downgradient groundwater migrating toward Courthouse Bay.
- LTM of groundwater outside of active treatment areas to evaluate the effectiveness of MNA.
- LUC implementation for groundwater and soil as follows:
 - To prohibit human consumption of groundwater from the surficial and Castle Hayne aquifers underlying Site 73.
 - To prohibit residential/recreational uses and development at the site including, but not limited to, any form of housing, any kind of school, child-care facilities, playgrounds, and adult nursing facilities.
 - To prohibit unauthorized intrusive activities in areas with contaminated soil.
 - To maintain the integrity of any existing or future monitoring or remediation system at the site such as monitoring wells, concrete cover, and horizontal AS system.

18.5 Remedy Implementation

Air Sparging

The AS system includes a 1,170-foot long HDD well with a 400-foot well screen, installed to 88 feet bgs. The AS HDD well was designed to deliver air at a rate of approximately 120 scfm across the well screen, promoting mass transfer and/or aerobic biological degradation of CVOCs. Construction details for the AS system can be found in the RD (CH2M HILL, 2010) and the IRACR (Shaw, 2011).

Biobarrier

The downgradient ERD biobarrier consists of 17 vertical injection wells, spaced 40 feet apart, each located between 100 and 150 feet from Courthouse Bay and screened within the partially cemented sandy horizon UCH aquifer (approximately 55 to 65 feet bgs). The initial injection event was completed in June 2011. The amendments injected into each of the injection wells included 484 gallons of a 10 percent three-dimensional microemulsion (3DMe) substrate solution, 13,600 gallons of anaerobic chase water, approximately 1.2 liters (L) of Terra Systems Incorporated DC Bioaugmentation/DHC (SDC-9 [TSI-DC]) culture at a concentration of 1x10¹⁰ cells per milliliter (mL), and another 14,000 gallons of anaerobic chase water (Shaw, 2011). Semi-annual performance monitoring of 3 upgradient and 3 downgradient monitoring wells is currently being conducted as part of the LTM program.

Long-term Monitoring and Land Use Controls

LTM was initiated in 2010 and is ongoing. The LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

18.5.1 Remedy Operation and Maintenance

Air-Sparge System

The AS system operated from October 2010 to March 2012 when RAOs within the zone of influence (100 feet of the AS well) were met (CH2M HILL, 2013). The operational air flow rate ranged from 80 to 85 scfm. O&M of the system consisted of preventative maintenance as prescribed by the air compressor manufacturer, maintaining the

ES120414012346RAL 18-3

compressed air system enclosure, and conducting any unanticipated repairs. After completion of the remedy, the air compressor and associated components were removed from the site and reused for a Treatability Study at a RCRA site. However, the HDD well is currently intact in the event that sparging needs to be restarted due to rebounding.

While the AS was operating, performance monitoring included quarterly sampling of 3 surficial, 7 UCH, and 2 MCH aquifer monitoring wells for VOC analysis.

Subslab soil gas samples were collected from four locations within Building A-47 during operation of the AS system to evaluate potential VI pathways. During operation, TCE concentrations exceeded non-residential soil gas screening levels in one location. After shut-down, all COCs were detected below screening levels during one year of quarterly post-operation monitoring, indicating that VI is not currently a complete pathway and will not likely be a complete pathway if the AS system remains shut down (CH2M HILL, 2014).

Biobarrier

Groundwater samples are collected semiannually from three upgradient and three downgradient performance monitoring wells for site-specific COCs and NAIPs, including TOC, volatile fatty acids, and DHC to evaluate the effectiveness of the biobarrier. Substrate injections will continue until COC concentrations upgradient are reduced below the cleanup levels or until groundwater modeling indicates that COC concentrations have been reduced to levels that are protective of public health and the environment. During the July 2012 LTM sampling event, the range of TOC concentrations had significantly decreased, indicating minimal available substrate. Additionally, the microbial data was not ideal for ERD (0.9 to 6.5 cells/mL reported in March 2013). The FY 2012 LTM report concluded that the ERD substrate was mostly spent and a second injection event was recommended to further stimulate the biological treatment of groundwater COCs in the subsurface.

The second round of substrate and bioaugmentation injections was completed in December 2013. The injections were conducted to closely replicate the first round of injection with slight modifications based on product availability. The amendments injected into each of the injection wells included 1.3 L of SDC-9 (TSI-DC) culture, 73 gallons of 3DMe substrate concentrate, 660 gallons of dilute chase water, and 150 gallons of anaerobic chase. Additional chase water ranged from 0 to 27,198 gallons based on low injection rates. A total of 11 injection wells did not receive any chase water due to low flow rates during the substrate and initial chase water injections (Osage, 2014).

Performance monitoring currently includes semi-annual sampling of 6 UCH aquifer monitoring wells for analysis of VOCs and NAIPs.

Long-term Monitoring

MNA at Site 73 initially consisted of collecting groundwater samples from 7 surficial, 14 UCH, and 3 MCH aquifer monitoring wells for VOCs. After the AS system was turned off, the LTM network was expanded to include the former AS performance monitoring wells and currently includes 12 surficial, 16 UCH, and four MCH aquifer monitoring wells. Samples are analyzed annually for VOCs and every five years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. Sampling locations are shown on **Figure 18-1**.

Light non-aqueous phase liquid (LNAPL) is periodically measured in IR73-MW14 with no discernable trend; however, historical groundwater samples collected when LNAPL was not measured have not been shown to contain elevated concentrations of VOCs or SVOCs, suggesting that the LNAPL does not appear to contain appreciable concentrations of VOCs. Free product monitoring and recovery (using an oil-absorbent sock) is being conducted monthly.

PDBs are used for VOC sampling in all monitoring wells with the exception of biobarrier performance monitoring wells and when NAIPs are being collected.

The annual cost of LTM and performance monitoring at OU 21 is approximately \$90,000.

18-4 ES120414012346RAL

Land Use Controls

LUCs are summarized in **Table 18-3** and shown on **Figure 18-1**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

TABLE 18-3 OU 21 LUC Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Intrusive Activities Control Boundary (Soil)	0.8	Contambor 2010	August 2010
Aquifer Use Control (1,000 feet)	47.1	September 2010	August 2010

18.5.2 Progress since the 2010 Five-Year Review

Issues identified during the 2010 FYR and follow-up actions are summarized in **Table 18-4**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 18-2**.

TABLE 18-4 2010 FYR OU 21 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Current Status
Potential for VI pathway	Evaluate and mitigate VI pathway during construction planning. (ongoing)	Ongoing. Building A47 was investigated during the Basewide VI investigation. TCE was identified as a COC in subslab soil vapor and increasing concentrations were observed during AS system operations. After system shut-down, soil gas monitoring indicated that the VI pathway was not complete under current conditions (CH2M HILL, 2015). If buildings are planned for construction in the vicinity of the VOC groundwater plume, the potential for a VI pathway is evaluated and mitigated if needed. Base Master Planning maintains current groundwater plume data in the GIS, and all construction projects on-Base go through environmental review.

18.6 Technical Assessment

Is the remedy functioning as designed?

Yes, the remedy is functioning as designed, COC concentrations are decreasing, and the bio-barrier is protective of Courthouse Bay. **Figures 18-3** through **18-7** show the concentrations of cis-1,2-DCE and VC in the surficial, and TCE, cis-1,2-DCE, and VC in the UCH aquifers for 2008 (data used during remedy selection), 2012 (AS system shutdown), and the most recent round of LTM (2014). **Figures 18-8** and **18-9** show the concentrations of benzene in the surficial and UCH aquifers for 2008, 2012, and 2014.

Monitored Natural Attenuation

The MNA data indicate that after the AS system was shut down, COCs have continued to decrease. Concentrations of cis-1,2-DCE in the surficial aquifer have decreased since the ROD and continued to decrease after the AS system was shut off in 2012 (**Figure 18-3**). Concentrations of VC in the surficial aquifer initially increased between 2008 and 2012 and show a decreasing trend after 2012 (**Figure 18-4**). Reductive dechlorination of parent products may have contributed to the initial increase. Concentrations of TCE in the UCH aquifer are decreasing or stable and the majority of the samples collected in 2012 and 2014 were below the cleanup level (**Figure 18-5**). Concentrations of

ES120414012346RAL 18-5

cis-1,2-DCE and VC in the UCH have continued to decrease since the AS system was shut down (**Figure 18-6** and **18-7**).

Concentrations of benzene in the surficial and UCH aquifers appear to be stable to slightly decreasing in the area where the AS system was present. However, concentrations in the UCH aquifer appear to be increasing slightly in downgradient groundwater (**Figure 18-8** and **18-9**). Concentrations of benzene in downgradient samples are within one order of magnitude of the NCGWQS ($1 \mu g/L$) and do not exceed the NCSWQS ($51 \mu g/L$).

A summary of NAIP data is provided in **Table 18-5**. Conditions in the surficial and UCH aquifer are generally favorable for reductive dechlorination. Two years after the AS was turned off, geochemical parameters in the UCH aquifer appear to have returned to pre-treatment conditions. Favorable indicators for reductive dechlorination included ORP (negative or less than 50 mV), nitrate in the UCH aquifer (low or not detected), ferrous iron (measurable levels), and sulfate in the surficial aquifer (not detected or low concentrations). TOC in both aquifer zones was low, which may be unfavorable for microbial growth.

Biobarrier

The biobarrier appears to be effective in creating a zone of reductive dechlorination in the UCH aquifer. TCE and cis-1,2-DCE were not observed in samples collected downgradient from the biobarrier, and VC concentrations continue to decrease in downgradient monitoring wells (**Figure 18-7**). Conditions in the biobarrier performance monitoring wells continue to be favorable for reductive dechlorination. Favorable indicators include ORP (negative), DO (less than 1 mg/L), and the presence of microbes.

LUCs

LUCs remain in place to prohibit aquifer use and non-industrial land use.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. The final ROD (CH2M HILL, 2009c) identified the cleanup levels for groundwater as the more conservative of the Federal MCLs or NCGWQS and NCDENR soil-to-groundwater protection concentration for PAH-fraction class C11-C22 in subsurface soil, which have changed slightly (**Table 18-1**). In all cases, the updated cleanup level is higher than the ROD cleanup level and LTM and LUCs are ongoing until COCs are below cleanup levels.

Changes in Exposure Pathways: Although no current significant pathway of concern for VI was identified during the Basewide VI studies (CH2M HILL, 2009b and 2014a), consideration of the VI pathway is recommended during construction planning within 100 feet of VOC-impacted groundwater.

Changes in Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs (Table 2-1), the remedy is to maintain LUCs to prevent exposure to contaminated soil and prevent the use of groundwater until groundwater concentration reduction to levels that allow for UU/UE. Additionally, the more conservative of the Federal MCLs or NCGWQS was identified as the groundwater cleanup level, and these values have not changed since the ROD was signed. Thus, toxicity changes for any of the chemicals detected at the site would not affect the protectiveness of the remedy.

An RSL was established for 1,4-dioxane. In 2002, the USEPA collected groundwater samples at Site 73 to confirm the presence or absence of 1,4-dioxane. Analytical results were below detection limits (**Attachment C**).

Has any other information come to light that could question the protectiveness of the remedy?

Yes. The VI pathway has the potential to become complete at OU 21 and an RAO and LUCs should be added to include mitigating exposure via this pathway.

18-6 ES120414012346RAL

18.7 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 21 are summarized in Table 18-6.

TABLE 18-6
OU 21 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight		Affects Protectiveness (Y/N)	
		Kesponsible	Agency		Current	Future
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI).	Navy/Base	USEPA/State	6/30/2016	N	Υ

18.8 Statement of Protectiveness

The remedy for groundwater and soil at OU 21 will be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled through LUCs for groundwater. The Base maintains all current COC plumes in GIS and Master Planning processes to prevent unacceptable exposure for potential VI pathways. The horizontal AS system has treated the highest VOC concentrations in groundwater and substrate injections will be continued to prevent impact to the adjacent surface water body. LUCs to prohibit aquifer use and intrusive soil activities are in place until cleanup levels for UU/UE are achieved.

18.9 References

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Shaw. 2011. Interim Remedial Action Completion Report for Operable Unit 21 – Site 73, Marine Corps Base Camp Lejeune, North Carolina. August.

18-8 ES120414012346RAL

TABLE 18-1 Cleanup Levels for OU 21 (Site 73)

Five-Year Review

Camp Lejeune, North Carolina

Media	200	ROD Cleanup Levels	Current Cleanup Level			
	COCs	(CH2M HILL, 2009)	Concentration	Reference		
	VOCs					
	1,1-Dichloroethene	7	7	NCGWQS/MCL		
Croundwater (ug/l)	Benzene	1	1	NCGWQS		
Groundwater (μg/L)	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL		
	Trichloroethene	2.8	3	NCGWQS		
	Vinyl chloride	0.015	0.03	NCGWQS		
Soil (mg/kg)	Petroleum Aromatic Carbon Fraction Class C9-C22	33.6	34	UST Program Soil to Groundwater Maximum Soil Contaminant Concentration (April 2012)		

Cleanup Level Reference Dates:

MCL (May 2009) NCGWQS (April 2013)

TABLE 18-2
OU 21 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review
Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
	Soil	Potential unacceptable risks to future adult and child residents from exposure to PAHs in soil.		Prevent future residential exposure to petroleum hydrocarbon-contaminated soils above the NC SSL and minimize transport to groundwater.	LUCs	Maintain intrusive activities controls and monitor quarterly.	Industrial Land Use
				Restore groundwater quality at Site 73 to the NCGWQS and MCL standards based on the classification of the aquifer	Air Sparging	Operate the air sparge system for up to 5 years or until the remedial goals within the radius of influence were met. The AS system was shut down in March 2012 when performance metrics were met.	e were 12
	73 residents from groundwater. Groundwater Potential una future Base p from exposur	Potential unacceptable risk to future residents from exposure to VOCs in groundwater. Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.	unacceptable risk to future from exposure to VOCs in ater. Industrial/ Maintenance unacceptable risks to se personnel and residents osure to VOCs in indoor air	as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.	MNA	Implement groundwater LTM/MNA to monitor VOC concentrations and migration until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	
73				Minimize migration of COCs in groundwater to surface water.		Inject ERD substrate to create a biobarrier upgradient to the New River. The biobarrier will be maintained until VOCs are below cleanup levels or modeling indicates concentrations are protective of the New River.	UU/UE
				Prevent human ingestion of water containing COCs (benzene, TCE, cis-1,2-DCE, 1,1-DCE, and VC) at concentrations above NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.	LUCs	Maintain aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	
				Prevent future exposure to COCs in indoor air via the VI pathway.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	

Notes

Shading indicates Risks/Basis of Action resulting from changing site conditions, exposure pathways, or assumptions that were not present at the time of the ROD. Proposed RAO, Remedy Component, and Performance Metric are included.

TABLE 18-5
Site 73 Summary of NAIPs - March 2014
2015 Five-Year Review

Camp Lejeune, North Carolina

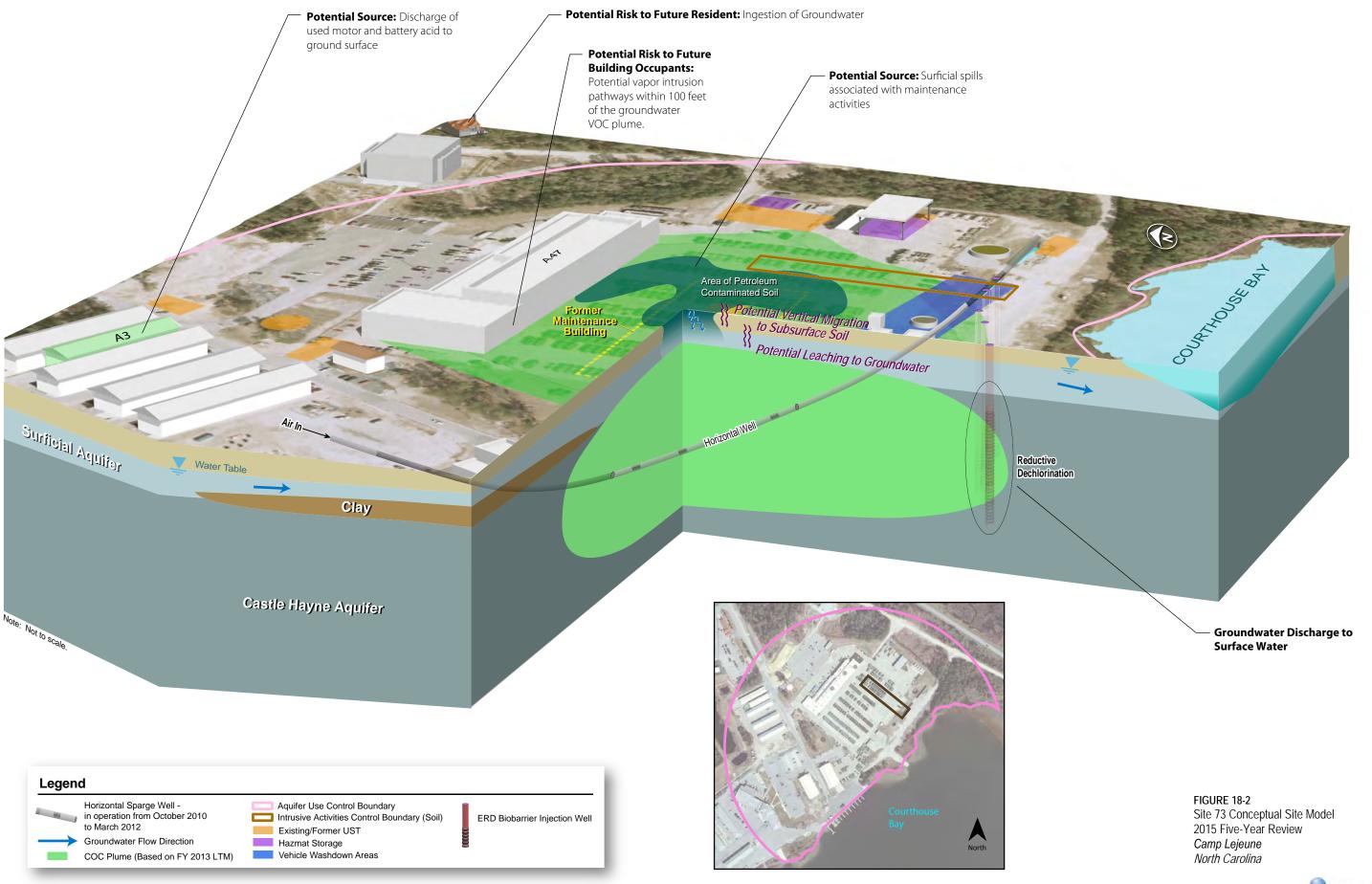
Indicator Parameter	Range of Results	Condition for favorable reductive pathway
Surficial Aquifer (within plume are	a)	
ORP (mV)	-100 to 28.8	Less than +50 mV (favorable)
OKF (IIIV)	-100 to 28.8	Less than -100 mV (ideal)
DO (mg/L)	0.25 to 0.38	Less than 1.0 mg/L
Nitrate (mg/L)	0 to 17	Less than 1.0 mg/L
Ferrous Iron (mg/L)	1 to 1.2	Measurable Levels
Sulfate (mg/L)	3.54 to 52.3	Less than 20 mg/L
Alkalinity (mg/L)	130 to 314, average 204	2x Above ¹ Background (160)
Chloride (mg/L)	7.44 to 20, average 12	2x Above ¹ Background (22)
Methane (μg/L)	633 to 1,310	>500 μg/L
Total Organic Carbon (mg/L)	5.53 to 29	>20 mg/L
Upper Castle Hayne Aquifer (MNA	wells within plume area)	
ORP (mV)	-103.4 to -13.4	Less than +50 mV (favorable)
ORP (IIIV)	-105.4 t0 -15.4	Less than -100 mV (ideal)
DO (mg/L)	0.06 to 1.09	Less than 1.0 mg/L
Nitrate (mg/L)	0 to 3.5	Less than 1.0 mg/L
Ferrous Iron (mg/L)	1.14 to 6	Measurable Levels
Sulfate (mg/L)	0.525 to 1,970	Less than 20 mg/L
Alkalinity (mg/L)	191 to 364, average 288	2x Above ¹ Background (191.5)
Chloride (mg/L)	26.2 to 123, average 59	2x Above ¹ Background (11.2)
Methane (μg/L)	2.16 to 5,880	>500 μg/L
Total Organic Carbon (mg/L)	2.51 to 14.9	>20 mg/L
Upper Castle Hayne Aquifer (Bioba	arrier performance monitoring well	(s)
ODD (***)/)	1201- 607	Less than +50 mV (favorable)
ORP (mV)	-130 to -60.7	Less than -100 mV (ideal)
DO (mg/L)	0.15 to 1.74	Less than 1.0 mg/L
DHC (cells/mL)	2.6 to 994	>1,000
Total Organic Carbon (mg/L)	2.19 to 11.6	>20 mg/L

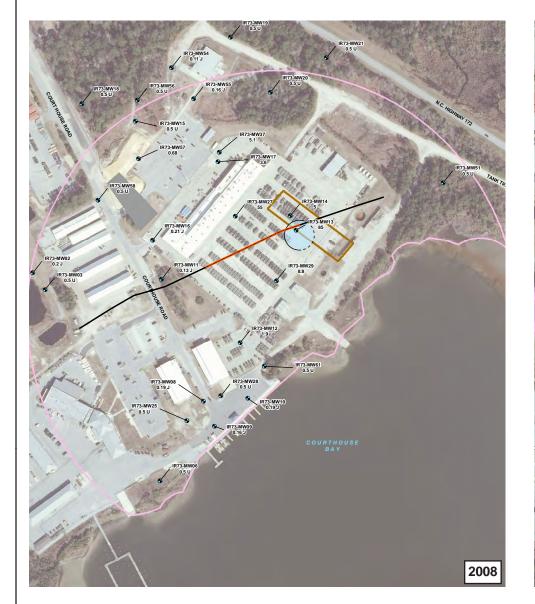
Notes:

¹Background data from monitoring wells outside of historical plume area:

Surficial - IR73-MW16, and A47/3-12,

Upper Castle Hayne Aquifer - IR73-MW26IW, and -MW43DW









Legend Monitoring Well Surficial Aquifer ERD Injection Well Horizontal Well and Screened Interval Land Use Control Boundaries Aquifer Use Control Boundary Intrusive Activities Control Boundary (Soil)

cis-1,2-DCE Extent >70 µg/L

DCE - Dichloroethene

Notes:

cis-1,2-DCE NCGWQS - 70 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

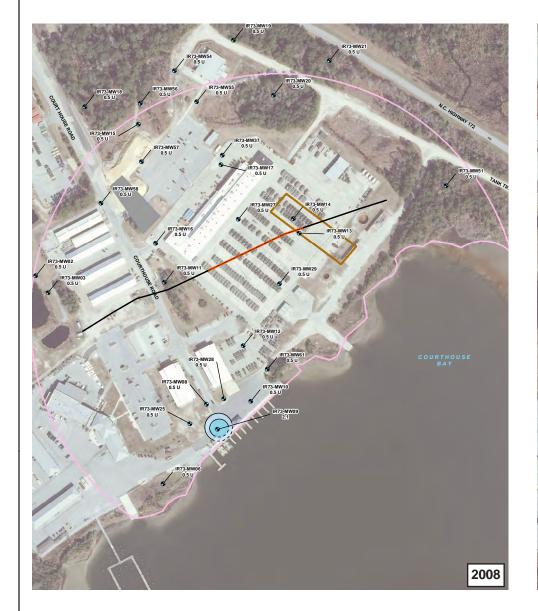
J - concentration is estimated

* - not sampled during LTM event

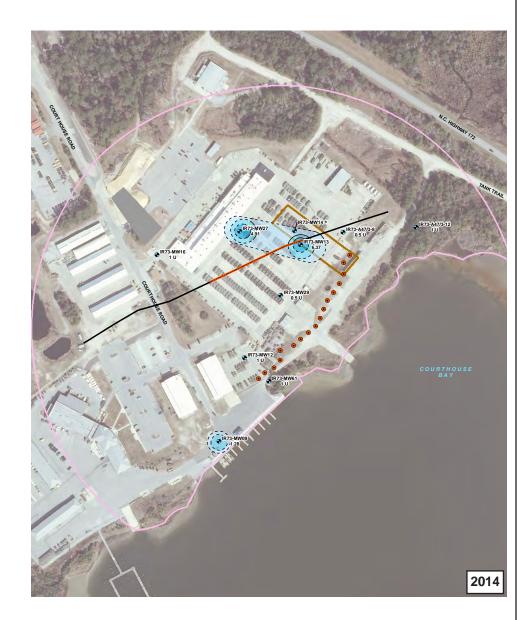
The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2014 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 18-3
Site 73
Approximate Extent of cis-1,2-DCE
Exceedances in the Surficial Aquifer
2015 Five-Year Review
Camp Lejeune
North Carolina









Legend **Monitoring Well** Surficial Aquifer ERD Injection Well Horizontal Well and Screened Interval

Land Use Control Boundaries Aquifer Use Control Boundary Intrusive Activities Control Boundary (Soil)

3 μg/L - 30 μg/L

VC Extent (dashed where inferred)
0.03 μg/L - 0.3 μg/L
VC - Vir VC - Vinyl Chloride 0.3 μg/L - 3 μg/L

VC NCGWQS - 0.03 μg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

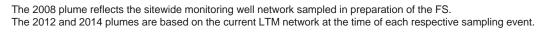
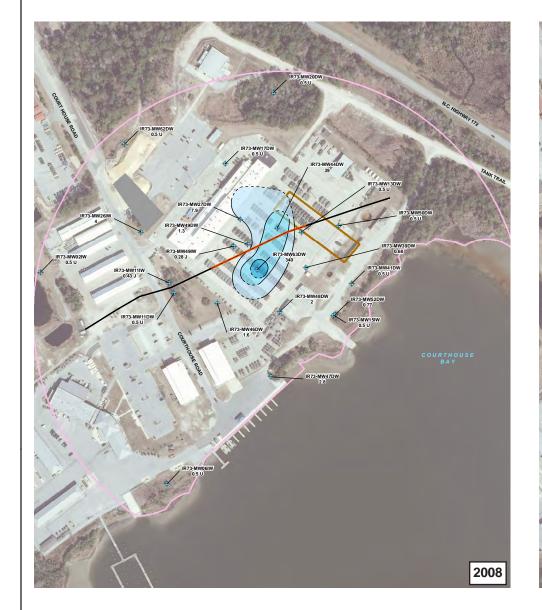
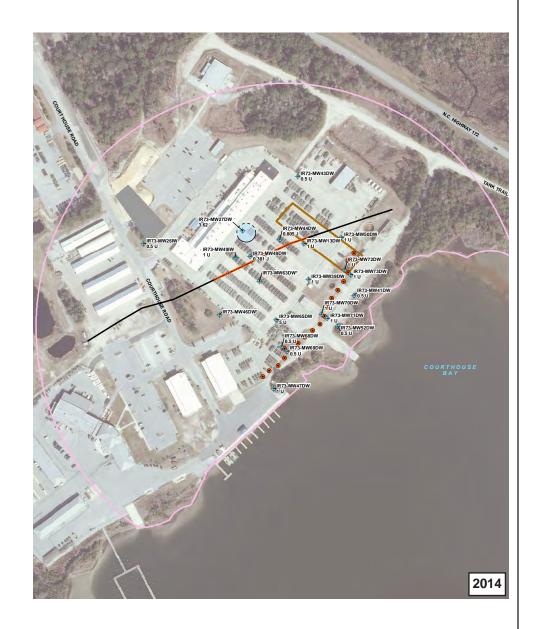


Figure 18-4 Site 73 Approximate Extent of VC
Exceedances in the Surficial Aquifer
2015 Five-Year Review Camp Lejeune North Carolina









Legend

Monitoring Well

→ UCH Aquifer

ERD Injection Well

Horizontal Well and Screened Interval

Land Use Control Boundaries

Aquifer Use Control Boundary Intrusive Activities Control Boundary (Soil)

TCE Extent (dashed where inferred)

3 µg/L - 30 µg/L 30 µg/L - 300 µg/L >300 µg/L

Notes: TCE - Trichloroethene

TCE NCGWQS - 3 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

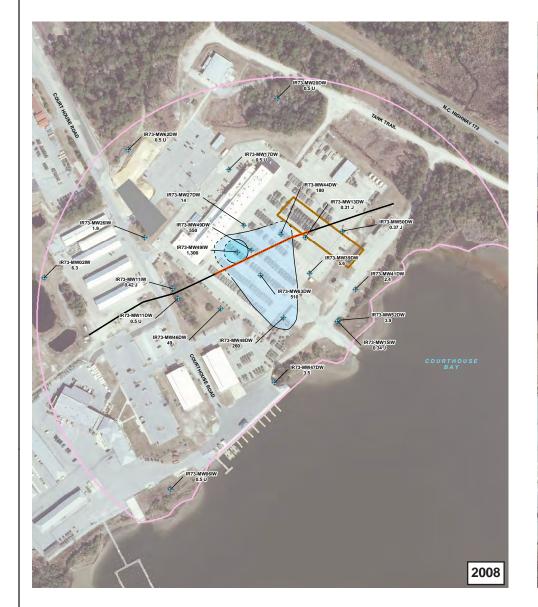
U - analyte not detected above detection limit

J - concentration is estimated

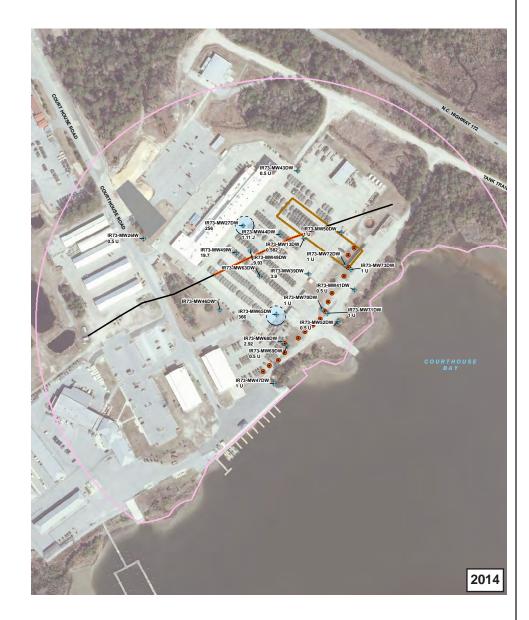
The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2014 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 18-5 Site 73 Approximate Extent of TCE Exceedances in the UCH Aquifer 2015 Five-Year Review Camp Lejeune North Carolina









Legend Monitoring Well UCH Aquifer ERD Injection Well Horizontal Well and Screened Interval Land Use Control Boundaries Aquifer Use Control Boundary Intrusive Activities Control Boundary (Soil)

cis-1,2-DCE Extent
70 μg/L - 700 μg/L
>700 μg/L

Notes: DCE - Dichloroethene

cis-1,2-DCE NCGWQS - 70 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard $\mu g/L$ - micrograms per liter

U - analyte not detected above detection limit J - concentration is estimated

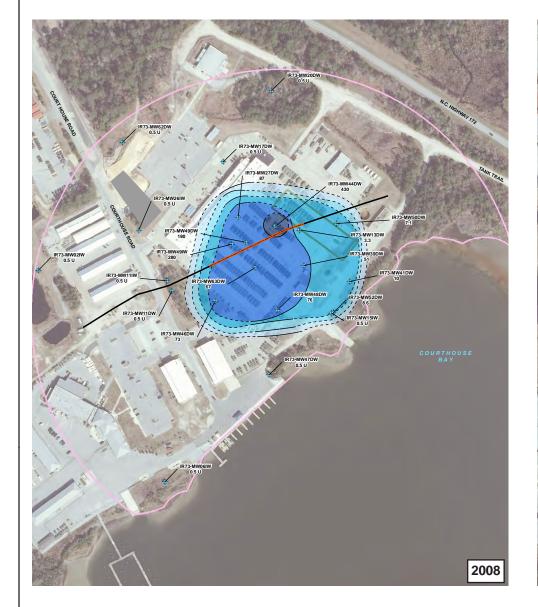


The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS.

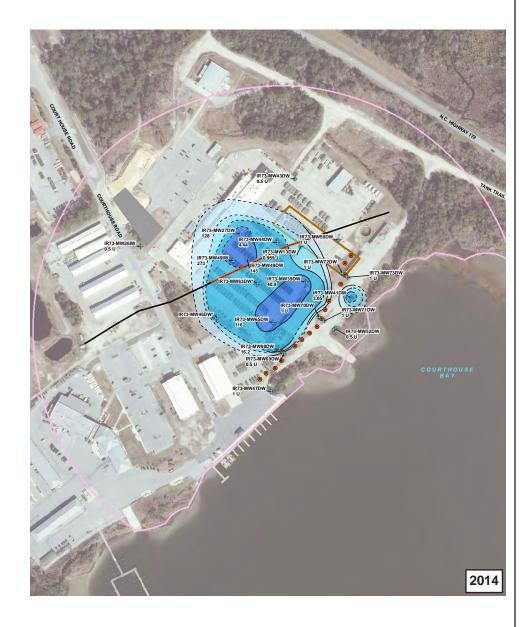
The 2012 and 2014 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 18-6
Site 73
Approximate Extent of cis-1,2-DCE
Exceedances in the UCH Aquifer
2015 Five-Year Review
Camp Lejeune
North Carolina









Legend **Monitoring Well** UCH Aquifer ERD Injection Well Horizontal Well and Screened Interval **Land Use Control Boundaries** Aquifer Use Control Boundary

Intrusive Activities Control Boundary (Soil)

 VC Extent (dashed where inferred)
 Notes:

 0.03 μg/L - 0.3 μg/L
 VC - Vin

 0.3 μg/L - 3 μg/L
 VC NCG

 3 μg/L - 30 μg/L
 NCGWC

 30 μg/L - 300 μg/L
 NCGWC

>300 µg/L

VC - Vinyl Chloride VC NCGWQS - 0.03 μg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard μg/L - micrograms per liter

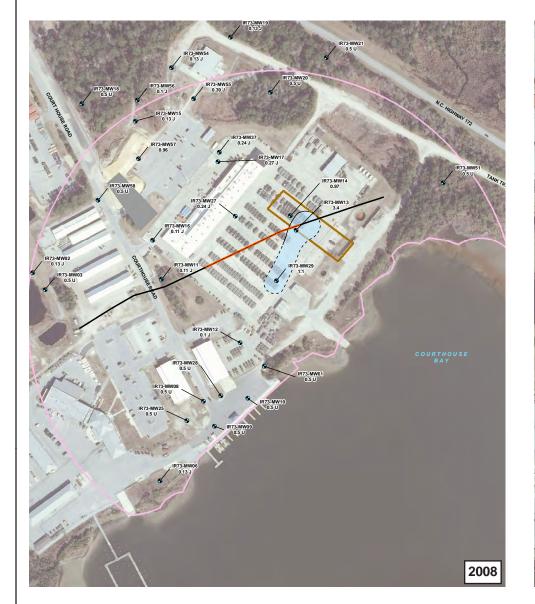
U - analyte not detected above detection limit

J - concentration is estimated

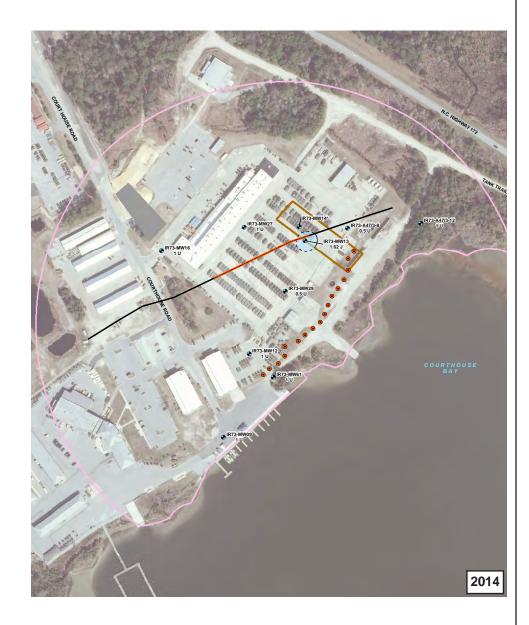
The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2014 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 18-7 Site 73 Approximate Extent of VC
Exceedances in the UCH Aquifer
2015 Five-Year Review Camp Lejeune North Carolina









Legend

Monitoring Well

Surficial Aquifer

ERD Injection Well

Horizontal Well and Screened Interval

Intrusive Activities Control Boundary (Soil)

Land Use Control Boundaries

Aquifer Use Control Boundary

Benzene Extent (dashed where inferred) 1 µg/L - 10 µg/L

Benzene NCGWQS - 1 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard

NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter
U - analyte not detected above detection limit

J - concentration is estimated

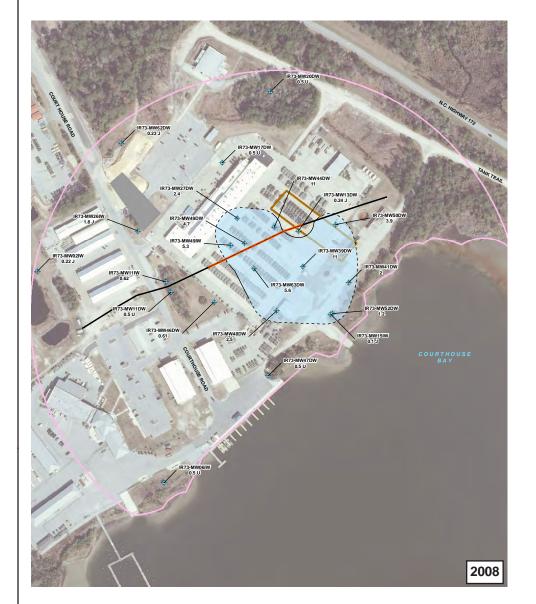
N 200 400

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS.

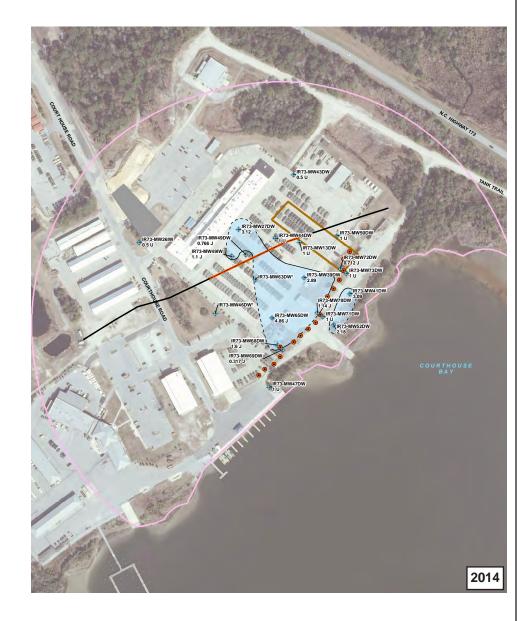
The 2012 and 2014 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 18-8 Site 73 Approximate Extent of Benzene Exceedances in the Surficial Aquifer 2015 Five-Year Review Camp Lejeune North Carolina









Legend

Monitoring Well

UCH Aquifer

ERD Injection Well

Horizontal Well and Screened Interval

Land Use Control Boundaries

Aquifer Use Control Boundary Intrusive Activities Control Boundary (Soil)

Benzene Extent (dashed where inferred) 1 μg/L - 10 μg/L

Benzene NCGWQS - 1 µg/L (April 2014)

NCGWQS - North Carolina Groundwater Quality Standard NCGWQS - North Carolina Groundwater Quality Standard

μg/L - micrograms per liter

U - analyte not detected above detection limit

J - concentration is estimated

The 2008 plume reflects the sitewide monitoring well network sampled in preparation of the FS. The 2012 and 2014 plumes are based on the current LTM network at the time of each respective sampling event.

Figure 18-9 Site 73 Approximate Extent of Benzene
Exceedances in the UCH Aquifer
2015 Five-Year Review Camp Lejeune North Carolina



Operable Unit 23 (Site 49)

19.1 Site History and Background

OU 23 is within MCAS New River (Figure 1-2) and consists of Site 49.

Site 49 – The MCAS Suspected Minor Dump is approximately 1 acre located along the New River (Figure 19-1). The dates of operation are unknown, but Site 49 is suspected of having been used for the disposal of paint cans. A building is located approximately 50 feet from the northeast boundary of the site and is currently used for the storage of miscellaneous industrial materials and paint supplies. Various types of construction-related surface debris have been observed at the site.

1983	•IAS	
2009- 2011	•PA/SI	
2011- 2012	•RI/FS	
2013	•PRAP	
2014	•ROD and RA (LUCs and LTM)	

19.2 Site Characterization

The findings from various investigations at OU 23 pertinent to the FYR are summarized in this section.

19.2.1 Physical Characteristics

- Surface Features Site 49 is primarily flat and covered with maintained grass in the northwestern portion of the site and woods in the southeastern portion. There is a steep drop to the New River that becomes less pronounced moving southeast. The ground surface slopes gently toward a drainage feature in the wooded portion of the site. The drainage feature is the ultimate discharge location for a series of ditches that collect a portion of the stormwater runoff from the MCAS, including taxiways, runways, and miscellaneous buildings along Curtis Road and Longstaff Street.
- Geology and Hydrogeology Subsurface conditions generally consist of Coastal Plain deposits that include sands, silts, clays, and cemented sands. From ground surface, a thin silty sand layer (0 to 3 feet thick) overlies a fine-grained sandy clay and clay deposit that extends to approximately 15 feet bgs. Isolated lenses of sand, woody debris, and brick were encountered within this unit near the New River. Beneath the clay, silty sand and weakly cemented sandy limestone with fossilized shells are present. Groundwater flows toward the New River in both aquifer zones (CH2M HILL, 2012).

19.2.2 Land Use

- Current Land Use A portion of the site (Building AS810) is currently used for storage, but the site is generally
 uninhabited.
- Future Land Use There are no anticipated changes in land use.

19.2.3 Site Characterization and Risk Assessment Results

This section describes the site characterization and risk assessments that led to the ROD. Details regarding the CSM are located in the RI/FS report (CH2M HILL, 2012) and the ROD (CH2M HILL, 2014a).

- VOCs, SVOCs, and metals in subsurface soil and VOCs and metals in surficial groundwater were detected at concentrations exceeding screening levels.
- A HHRA and ERA were completed during the PA/SI (CH2M HILL, 2011) and RI/FS (CH2M HILL, 2012). Potential
 unacceptable risks were identified for future residents from exposure to CVOCs in surficial groundwater if
 used as a potable source. There is also potential for the VI pathway to become complete if any buildings were

ES120414012346RAL 19-1

to be constructed within 100 feet of the VOC-impacted groundwater. No unacceptable ecological risks were identified.

19.3 Remedial Action Objectives

The ROD addressing groundwater at OU 23 was signed on March 4, 2014 (CH2M HILL, 2014a). The RAOs identified for OU 23 are:

- Restore groundwater quality to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE.
- Minimize potential degradation of the New River by COC-affected groundwater.

The cleanup levels for OU 23 are presented in **Table 19-1**.

19.4 Remedial Actions

The OU 23 RA components and expected outcomes are summarized in **Table 19-2**. The RA for OU 23 includes the following major components:

- LTM of groundwater and pore water to assess the effectiveness of MNA.
- LUC implementation for groundwater and VI as follows:
 - To prohibit human consumption of groundwater from the surficial aquifer underlying Site 49.
 - To prohibit residential/recreational uses and development at the site including, but not limited to, any form of housing, any kind of school, child-care facilities, playgrounds, and adult nursing facilities.
 - To mitigate the potential for future VI pathways.
 - To maintain the integrity of any existing or future monitoring system at the site such as monitoring wells.

19.4.1 Remedy Implementation

LTM was initiated in 2014 and is ongoing. LUCs were submitted to Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Planning.

19.4.2 Remedy Operation and Maintenance

Long-term Monitoring

LTM currently includes four surficial and one UCH aquifer monitoring wells and 2 pore water sampling locations. Samples are analyzed biennially for VOCs. Sampling locations are shown on **Figure 19-1**. The biennial cost of LTM at OU 23 is approximately \$10,000.

Land Use Controls

LUCs are shown on **Figure 19-1** and are summarized in **Table 19-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDENR from 2010 to 2014 are provided in **Appendix A**. A visual inspection of the site was conducted in March 2014 to evaluate LUCs and general site conditions (**Appendix B**). No unauthorized intrusions were observed during inspections.

19-2 ES120414012346RAL

TABLE 19-3
OU 23 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	37.6		
Industrial/Non-Industrial Use Control Boundary (VI)	0.5	April 2014	September 2014

19.4.3 Progress Since the 2010 Five-Year Review

This is the first FYR for OU 23. Since 2010, the site was investigated under a PA/SI (CH2M HILL, 2011) and RI/FS (CH2M HILL, 2012). Remedy evaluation was completed and the final remedy was selected (CH2M HILL, 2014a), LUCs were recorded in September 2014 to Onslow County, and LTM was initiated (CH2M HILL, 2014b). The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 19-2**.

19.5 Technical Assessment

Is the remedy functioning as designed?

Yes. LTM is being conducted to evaluate MNA and LUCs are in place to eliminate exposure to site COCs. The first round of samples were collected in June 2014. COCs in groundwater continue to be detected at concentrations exceeding cleanup levels in the sample collected from IR49-MW01, screened within the surficial aquifer. Based on the June 2014 results, the cleanup level for 1,1,2,2-PCA in groundwater has been achieved and the cleanup level for TCE is expected to be achieved within the 5 year time frame projected in the ROD. Trends will be re-evaluated as additional data are collected and presented in the LTM reports. Additionally, six COCs were detected in pore water (1,1,2,2-PCA, 1,1,2-TCA, benzene, cis- and trans-1,2-DCE, and TCE). There are no cleanup levels established for pore water and data trends will be used to assess potential migration into the New River.

Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid? Yes, all assumptions used in the ROD are still valid.

Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy.

19.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 23 during this review.

19.7 Statement of Protectiveness

The remedy for groundwater at OU 23 will be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. LTM to monitor groundwater COCs and LUCs to prohibit aquifer use and mitigate VI are in place until cleanup levels for UU/UE are achieved.

19.8 References

CH2M HILL. 2011. Preliminary Assessment/Site Inspection Report, Site 49, Marine Corps Air Station, Suspected Minor Dump. Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. March.

CH2M HILL. 2012. Remedial Investigation / Feasibility Study, Operable Unit No. 23, Site 49-Suspected Minor Dump Site, Marine Corps Installations East - Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. August.

ES120414012346RAL 19-3

CH2M HILL. 2014a. Record of Decision Site 49: Operable Unit No. 23, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina. March.

CH2M HILL. 2014b. *Interim Remedial Action Completion Report, Operable Unit 23, Site 49, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina*. November.

19-4 ES120414012346RAL

TABLE 19-1
Cleanup Levels for OU 23 (Site 49)

Five-Year Review

Camp Lejeune, North Carolina

Media	COCs	ROD Cleanup Levels (CH2M HILL, 2014)	Cleanup Level Reference	
	VOCs			
	1,1,2,2-Tetrachloroethane	0.2	NCGWQS	
	1,1,2-Trichloroethane	5	MCL	
	1,2-Dichloroethane	0.4	NCGWQS	
Croundwater (ug/L)	Benzene	1	NCGWQS	
Groundwater (μg/L)	cis-1,2-Dichloroethene	70	NCGWQS/MCL	
	Tetrachloroethene	0.7	NCGWQS	
	trans-1,2-Dichloroethene	100	NCGWQS/MCL	
	Trichloroethene	3	NCGWQS	
	Vinyl chloride	0.03	NCGWQS	

Cleanup Level Reference Dates:

MCL (May 2009)

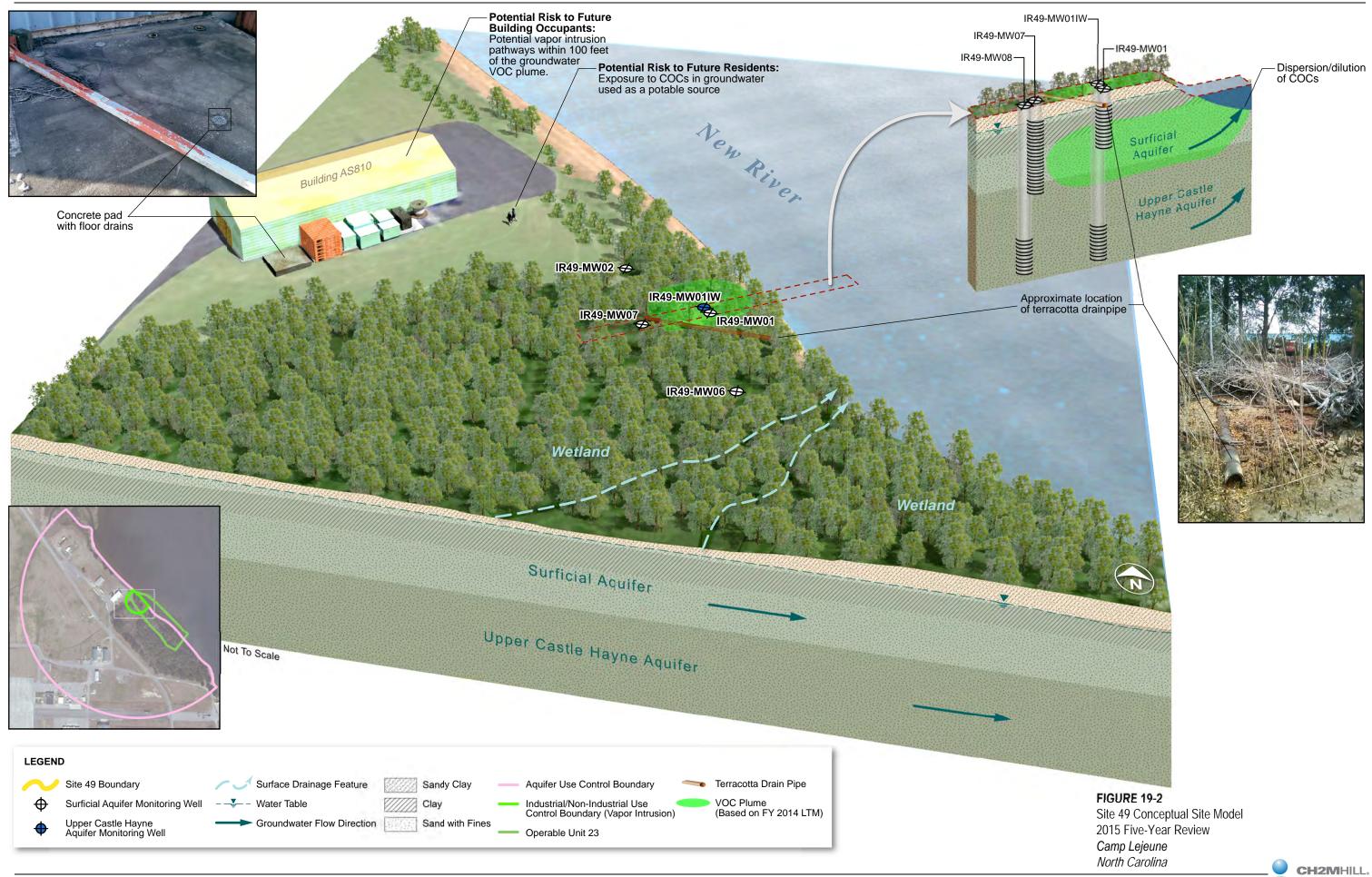
NCGWQS (April 2013)

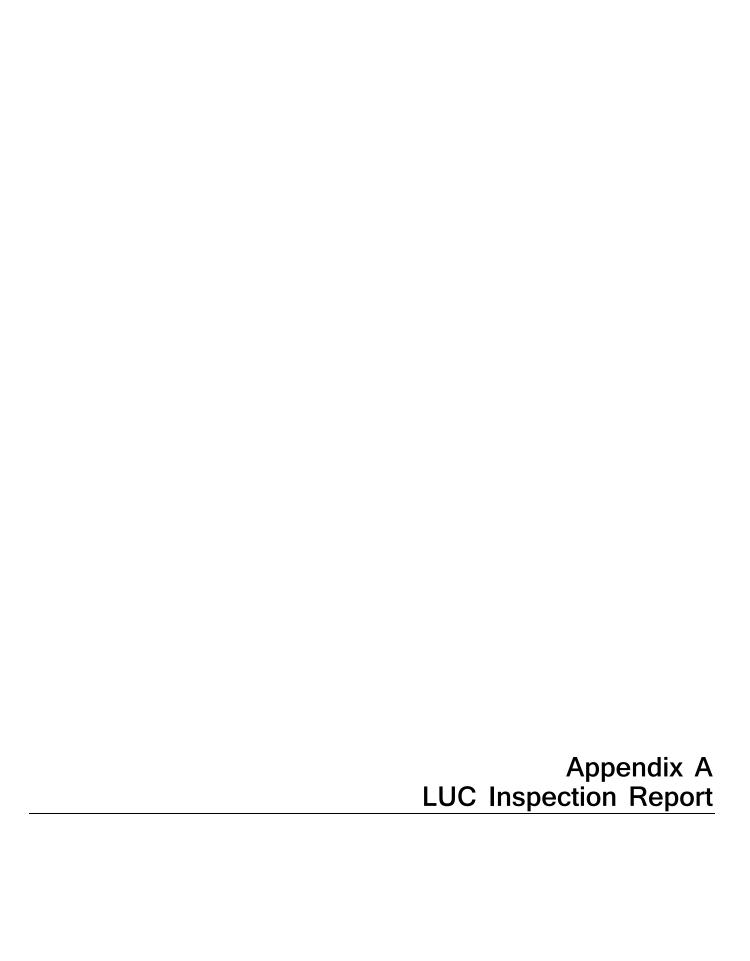
TABLE 19-2
OU 23 Remedial Action Summary and Expected Outcomes
2015 Five-Year Review

Camp Lejeune, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
49	Groundwater	Potential unacceptable risks to future child and adult residents from exposure to VOCs in groundwater and indoor	Industrial/Storage	Restore groundwater quality to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Minimize potential degradation of the New River by COC-affected groundwater.	MNA	Groundwater and pore water MNA to monitor VOC concentrations and migration to the New River until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	UU/UE
		air via the VI pathway.		Prevent exposure to COCs in groundwater and vapor intrusion from COCs in groundwater until such time as groundwater concentrations or vapor intrusion mitigation measures allow for UU/UE.	LUCs	Maintain industrial/non-industrial use and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	









UNITED STATES MARINE CORSERNANENT FILE

PSC BOX 20004
CAMP LEJEUNE, NC 28542-0004

Ms. Gena D. Townsend
United States Environmental Protection Agency
Region IV
Sam Nunn Atlanta Federal Center
61 Forsyth Street SW
Atlanta, GA 30303

Ms. Townsend:

This letter is being provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period May 14, 2009 to May 14, 2010. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) have had no violations affecting the land use controls. It further certifies that all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document. Furthermore, no major changes in land use have been discovered or planned for any of the OUs with LUCIPs.

The point of contact for this issue is Mr. Robert Lowder, Environmental Quality Branch, Environmental Management Division, Installations and Environment Department at (910) 451-5068.

Sincerely,

R. P. FLATAU, JR.

Colonel, U.S. Marine Corps

Commanding Officer

Copy to:

NAVFACENGCOM (Mr. Dave Cleland Code OPCEV)



UNITED STATES MARINE CORSERMANENT FILE

MARINE CORPS BASE
PSC BOX 20004
CAMP LEJEUNE, NC 28542-0004

5090.10 BEMD JUN 09 2010

Mr. Randy McElveen North Carolina Division of Waste Management Suite 150 401 Oberlin Road Raleigh, NC 27605

Mr. McElveen:

This letter is being provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period May 14, 2009 to May 14, 2010. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) have had no violations affecting the land use controls. It further certifies that all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document. Furthermore, no major changes in land use have been discovered or planned for any of the OUs with LUCIPs.

The point of contact for this issue is Mr. Robert Lowder, Environmental Quality Branch, Environmental Management Division, Installations and Environment Department at (910) 451-5068.

Sincerely,

R. P. FLATAU JR.

Colonel, U.S. Marine Corps

Commanding Officer

Copy to:

NAVFACENGCOM (Mr. Dave Cleland Code OPCEV)



UNITED STATES MARINE PERMANENT FILE

MARINE CORPS BASE
PSC BOX 20004
CAMP LEJEUNE NC 28542-0004

INREPLY REFER TO: 5090.10 BEMD

JUL 15 coll

Ms. Gena D. Townsend
US Environmental Protection Agency
Region IV
Sam Nunn Atlanta Federal Center
61 Forsyth Street Southwest
Atlanta, Georgia 30303

Dear Ms. Townsend:

This letter is being provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period May 14, 2010 to May 14, 2011. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) are in compliance with the land use controls (LUCs). However, during this reporting period an unauthorized intrusion of the LUC soil at Installation Restoration (IR) Site 74 was observed during the April 15, 2011, quarterly inspection event. Specifically, utility access manholes had been installed within the IR Site 74 boundary. The violation was guickly brought to the attention of the Officer in Charge of Construction (OICC) and the manholes were promptly removed and relocated outside the LUC boundary. This letter further certifies that all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

The point of contact for this issue is Ms. Charity Rychak, Environmental Quality Branch, Environmental Management Division, Installations and Environment Department at (910) 451-9385.

Sincerely,

Colone), U.S. Marine Corps

Commanding Officer

Copy to:
NAVFACENGCOM (Mr. Dave Cleland)

PEKMANENI FILE



UNITED STATES MARINE CORPS

MARINE CORPS BASE

PSC BOX 20004

CAMP LEJEUNE NC 28542-0004

10 1 5 2011

Mr. Randy McElveen North Carolina Department of Environmental and Natural Resources Suite 150 401 Oberlin Road Raleigh, North Carolina 27605

Dear Mr. McElveen:

This letter is being provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, guarterly inspections have been completed for the period May 14, 2010 to May 14, 2011. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) are in compliance with the land use controls (LUCs). However, during this reporting period an unauthorized intrusion of the LUC soil at Installation Restoration (IR) Site 74 was observed during the April 15, 2011, quarterly inspection event. Specifically, utility access manholes had been installed within the IR Site 74 boundary. The violation was quickly brought to the attention of the Officer in Charge of Construction (OICC) and the manholes were promptly removed and relocated outside the LUC boundary. This letter further certifies that all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

The point of contact for this issue is Ms. Charity Rychak, Environmental Quality Branch, Environmental Management Division, Installations and Environment Department at (910) 451-9385.

Sincerely,

Colonel, U.S. Marine Corps

Commanding Officer

Copy to:

NAVFACENGCOM (Mr. Dave Cleland)



MARINE CORPS INSTALLATIONS EAST-MARINE CORPS BASE PSC BOX 20005 CAMP LEJEUNE NC 28542-0005

> 1N REPLY REFER TO: 5090.10 EMD 21 JUN 2012

Ms. Gena D. Townsend US Environmental Protection Agency Region IV Sam Nunn Atlanta Federal Center 61 Forsyth Street Southwest Atlanta, Georgia 30303

Dear Ms. Townsend:

This letter is being provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period of May 14, 2011 through May 14, 2012. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) are in compliance with Land Use Controls (LUCs). However, during this reporting period, two occurrences of unauthorized intrusion of the soil intrusive LUC at Installation Restoration (IR) Site 06 were observed in October 2011 and February 2012. Both of these events were summarized in letters sent to your attention. In response to the multiple intrusion events at the same IR site, the Base has installed signs at various locations around IR Site 06 to better inform and deter personnel from conducting unauthorized digging.

This letter further certifies that all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

Point of contact is Ms. Charity Rychak, Environmental Quality Branch, Environmental Management Division, Installations, Facilities and Environment Department at (910) 451-9385.

Sincerely,

T. A. GORRY

Brigadier General, U. S./Marine Corps

Commanding General

Copy to:

NAVFACENGCOM (Mr. Dave Cleland)
IF&E/EMD/EQB (Ms. Charity Rychak)

FILE (ODI #14354)



MARINE CORPS INSTALLATIONS EAST-MARINE CORPS BASE PSC BOX 20005

CAMP LEJEUNE NC 28542-0005

IN REPLY REFER TO: 5090.10 EMD

2 1 JUN 2012

Mr. Randy McElveen North Carolina Department of Environment and Natural Resources Division of Waste Management Superfund Section 1646 Mail Service Center Raleigh, North Carolina 27699-1646

Dear Mr. McElveen:

This letter is being provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period of May 14, 2011 through May 14, 2012. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) are in compliance with Land Use Controls (LUCs). However, during this reporting period, two occurrences of unauthorized intrusion of the soil intrusive LUC at Installation Restoration (IR) Site 06 were observed in October 2011 and February 2012. Both of these events were summarized in letters sent to your attention. In response to the multiple intrusion events at the same IR site, the Base has installed signs at various locations around IR Site 06 to better inform and deter personnel from conducting unauthorized digging.

This letter further certifies that all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

Point of contact is Ms. Charity Rychak, Environmental Quality Branch, Environmental Management Division, Installations, Facilities and Environment Department at (910) 451-9385.

T. A. GORRY
Brigadier General, U.S. Marine Corps
Commanding General

Copy to:

NAVFACENGCOM (Mr. Dave Cleland) IF&E/EMD/EQB (Ms. Charity Rychak)

FILE (ODI #14354)



MARINE CORPS INSTALLATIONS EAST-MARINE CORPS BASE
PSC BOX 20005
CAMP LEJEUNE NC 28542-0005

5090 G-F

JUN 18 2013

Ms. Gena D. Townsend U.S. Environmental Protection Agency Region IV Sam Nunn Atlanta Federal Center 61 Forsyth Street Southwest Atlanta, Georgia 30303

Dear Ms. Townsend:

This letter is provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period of May 14, 2012 to May 14, 2013. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) are currently in compliance with the Land Use Controls (LUCs).

It should be noted that during this reporting period we observed two occurrences of unauthorized instances of the soil intrusive LUCs. An emergency action (utility repairs) requiring digging occurred at Installation Restoration (IR) Sites 6 and 82 (both sites are found within OU 2 and considered one occurrence) in February 2013. Soil rutting was observed at IR Site 84 in October 2012. Both of these events were summarized in letters previously sent to you.

Notwithstanding these discrepancies, all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

Point of contact is Ms. Charity Rychak, Environmental Quality Branch, Environmental Management Division, Installations, G-F, at (910)451-9385.

Sincerely,

THOMAS A. GORRY

Brigadier General, U.S. Marine Corps

Commanding Genéral

Copy to:

NAVFACENGCOM (Mr. Dave Cleland)

G-F/EMD/EQB



MARINE CORPS INSTALLATIONS EAST-MARINE CORPS BASE PSC BOX 20005 CAMP LEJEUNE NC 28542-0005

> 5090 G-F

JUN 1 8 2013

Mr. Randy McElveen
North Carolina Department of Environment
and Natural Resources
Division of Waste Management
Superfund Section
3rd Floor, Green Square Complex
1646 Mail Service Center
Raleigh, NC 27699-1646

Dear Mr. McElveen:

This letter is provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period of May 14, 2012 to May 14, 2013. This letter certifies that all Operable Units (OUs) with Land Use Control Implementation Plans (LUCIPs) are currently in compliance with the Land Use Controls (LUCs).

It should be noted that during this reporting period we observed two occurrences of unauthorized instances of the soil intrusive LUCs. An emergency action (utility repairs) requiring digging occurred at Installation Restoration (IR) Sites 6 and 82 (both sites are found within OU 2 and considered one occurrence) in February 2013. Soil rutting was observed at IR Site 84 in October 2012. Both of these events were summarized in letters previously sent to you.

Notwithstanding these discrepancies, all OUs with LUCIPs remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

Point of contact is Ms. Charity Rychak, Environmental Quality Branch, Environmental Management Division, Installations, G-F, at (910)451-9385.

Sincerely,

THOMAS A. GORKY

Brigadier Gerheral, U.S. Marine Corps

Commanding General

mm a lfam

Copy to:
NAVFACENGCOM (Mr. Dave Cleland)
G-F/EMD/EQB



MARINE CORPS INSTALLATIONS EAST-MARINE CORPS BASE
PSC BOX 20005
CAMP LEJEUNE NC 28542-0005

5090 G-F **2 0** JUN 2014

Ms. Gena D. Townsend U.S. Environmental Protection Agency Region IV Sam Nunn Atlanta Federal Center 61 Forsyth Street Southwest Atlanta, Georgia 30303

Dear Ms. Townsend:

This letter is provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period of May 2013 to May 2014. This letter certifies that all Installation Restoration (IR) Sites with Land Use Control Implementation Plans are currently in compliance with the Land Use Controls (LUCs).

During this reporting period, excavation within the soil intrusive LUC at Operable Unit 6, IR Site 54 occurred during construction of a concrete pad aboard the Marine Corps Air Station, New River. This event was presented to the Partnering Team during the May 2013 meeting and was summarized in a letter sent to your attention. The Partnering Team agreed to allow the construction to continue since the concrete pad will cover most or all of IR Site 54, thus capping the site.

Notwithstanding this discrepancy, LUCs at all IR Sites remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

Point of contact is Ms. Patti Vanture, Environmental Quality Branch, Environmental Management Division, Installations, G-F, at (910)451-9641.

Sincerely,

T. W. CLARK JR.

Colonel, NS. Marine Corps

Acting

Commander

Copy to:
NAVFACENGCOM (Mr. David Cleland)
G-F/EMD/EQB

File (ODI #20306)



MARINE CORPS INSTALLATIONS EAST-MARINE CORPS BASE PSC BOX 20005 CAMP LEJEUNE NC 28542-0005

> 5090 G-F

2 0 JUN 2014

Ms. Randy McElveen North Carolina Department of Environment and Natural Resources NC Superfund Section 1646 Mail Service Center Raleigh, North Carolina 27699-1646

Dear Mr. McElveen:

This letter is provided in compliance with the annual reporting requirement in the Memorandum of Agreement for the Land Use Control Assurance Plan (LUCAP). In accordance with the LUCAP, quarterly inspections have been completed for the period of May 2013 to May This letter certifies that all Installation Restoration (IR) Sites with Land Use Control Implementation Plans are currently in compliance with the Land Use Controls (LUCs).

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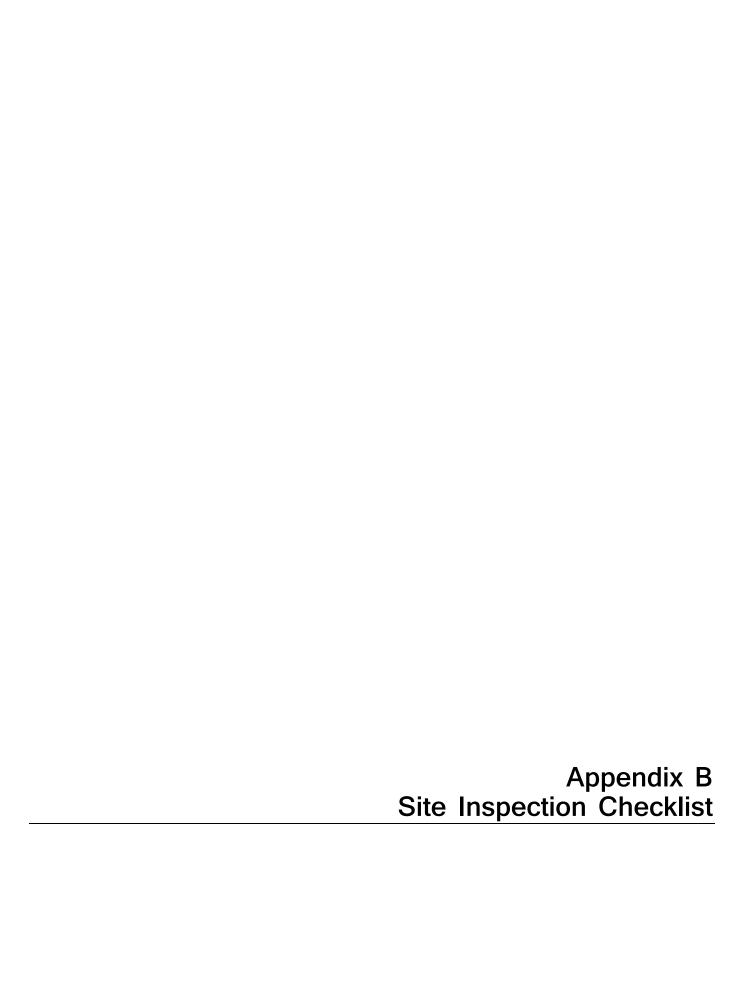
Notwithstanding this discrepancy, LUCs at all IR Sites remain protective and consistent with all remedial actions and corrective measures outlined in the decision document.

Point of contact is Ms. Patti Vanture, Environmental Quality Branch, Environmental Management Division, Installations, G-F, at (910) 451-9641.

Sincerely,

U.S. Marine Corps

Copy to: NAVFACENGCOM (Mr. David Cleland) G-F/EMD/EOB File (ODI #20307)



Five-Year Review Site Inspection Checklist

Inspector: Anclum Signature:		
Are institutional controls and LUCs properly implemented and fully enforced? If no, note on map and explain in Remarks below	□ Yes	□No
For active remediation systems, are the following components in good condition and wor f no, explain in Remarks below	king prop	erly?
. Pumps, and Electrical	□Yes	□No
i. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances	WYes	□No
ii. Treatment Technology	□Yes	□No
v. Discharge Structure and Appurtenances	□ Yes	□No
v. Recovery Wells	@Yes	MNo O
Do any observations indicate that RAOs are not being met? If yes, explain in Remarks	□Yes	No
Has land use on- or offsite changed? If yes, explain in Remarks	□Yes	XNo
Do monitoring wells at the site appear to be functioning, locked and in good condition? If no, explain in Remarks	XYes	□No
Is the area free of identifiable concerns, such as, signs of dumping of chemicals or debris, with regards to this site? If no, explain in Remarks	□ Yes)(No
Are there any previously undocumented features at the site (new roads, wetlands, changes in grade)? If yes, note on map; identify any effect on the remedy in Remarks below	Yes	□ №
Remarks:		
1) Recovery wells - Sample ports at RWG, 7,14 not in work	ing ord	v (CTM
- Significant construction @ 78 N along Smeds Fory Rd - Building being downdown (multiple places)		

Five-Year Review Site Inspection Checklist

Site name: 04 2 (6,82)	Date/Time:: 3/26/14	1015	43/27
Inspector: V. Bracianan B. REID	Signature:		
Are institutional controls and LUCs properly implement If no, note on map and explain in Remarks below	ed and fully enforced?	□ Yes	□ No
For active remediation systems, are the following compo If no, explain in Remarks below	nents in good condition and wor	king prop	erly?
i. Pumps, and Electrical		Ves Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, an	nd Other Appurtenances	M Yes	□No
iii. Treatment Technology		☑ Yes	□No
iv. Discharge Structure and Appurtenances		⊠ Yes	□No
v. Recovery Wells		>Yes	∠ No
Do any observations indicate that RAOs are not being m	et? If yes, explain in Remarks	□Yes	□No
Has land use on- or offsite changed? If yes, explain in Rer	narks	XYes €	□No
Do monitoring wells at the site appear to be functioning, If no, explain in Remarks	locked and in good condition?	□Yes	□ No
Is the area free of identifiable concerns, such as, signs of debris, with regards to this site? If no, explain in Remarks		Yes	□No
Are there any previously undocumented features at the schanges in grade)? If yes, note on map; identify any effect		□ Yes	□No
Remarks:			
- STIE 6 Land use - Lot 203 No	LONGER DRHO		
in wooded are set (el 203 +		restacto	in,
	re removal location re	in Athi	
haz waste site NOT For efficient		(
- SRW01 - LTM Q2 2014 NOT ON A	WO SAMPLE PORT BIG	NOT PE	ODYCELANT
- Evidence of Artesian condition @ +44	W- IR82-MWOSHLH,	thread	i
CAP HAS BEEN INSTALLED BUT WELL	The state of the s		
CATE			
Extende to FIELD TRAILER AREA	15 NOT LOCKED of N	TOTAL C	W.
WEEKENOS			

3127/14 0810

Site name: ()(1 4 (4) 74)	Date/Time:: 3/26/14 12	100
1/ 0 55	ature: Ma	.00
Are institutional controls and LUCs properly implemented and full If no, note on map and explain in Remarks below	ha-vo-	□No
For active remediation systems, are the following components in go If no, explain in Remarks below	od condition and working pro	perly?
i. Pumps, and Electrical	□ Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other A	ppurtenances	□No
iii. Treatment Technology	□ Yes	□No
v. Discharge Structure and Appurtenances	□Yes	□No
v. Recovery Wells	□ Yes	□No
Do any observations indicate that RAOs are not being met? If yes, e	explain in Remarks	No
Has land use on- or offsite changed? If yes, explain in Remarks	□ Yes	X No
Do monitoring wells at the site appear to be functioning, locked and If no, explain in Remarks		□No
Is the area free of identifiable concerns, such as, signs of dumping of debris, with regards to this site? If no, explain in Remarks	of chemicals or	No
Are there any previously undocumented features at the site (new rochanges in grade)? If yes, note on map; identify any effect on the reme	ads, wetlands,	No
Remarks:		
- SITE 41 - MUNHORIM WELLS WERE ABOVE	DENEO, PUCL BOLLARD)
DILED NEXT TO ENTRANCE		

Site name: SITE 2 (OUS)	Date/Time:: 3 27	19 0	008
Inspector: K. Brickman B. REID Signa	iture: LB	_	
Are institutional controls and LUCs properly implemented and full If no, note on map and explain in Remarks below	y enforced?	Yes	□No
For active remediation systems, are the following components in go- If no, explain in Remarks below	od condition and wor	king pro	perly?
i. Pumps, and Electrical		☐ Yes	□ No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other A	ppurtenances	□Yes	□No
iii. Treatment Technology		□ Yes	□No
iv. Discharge Structure and Appurtenances		□ Yes	□No
v. Recovery Wells		□Yes	□No
Do any observations indicate that RAOs are not being met? If yes, e	xplain in Remarks	□ Yes	X No
Has land use on- or offsite changed? If yes, explain in Remarks		□Yes	No
Do monitoring wells at the site appear to be functioning, locked and If no, explain in Remarks	in good condition?	□Yes	□No
Is the area free of identifiable concerns, such as, signs of dumping of debris, with regards to this site? If no, explain in Remarks	f chemicals or	Yes	□No
Are there any previously undocumented features at the site (new ro changes in grade)? If yes, note on map; identify any effect on the reme		□Yes	No
Remarks:			
			_== n
		_	
A CONTRACTOR OF THE PARTY OF TH			

1230-1245 (43,44)

lite name: 517 36,43,44,54 (OU 6)	Date/Time:: 3)26	14 16.	45 (3
nspector: K. Benden B.REID	Signature:		
re institutional controls and LUCs properly implemented f no, note on map and explain in Remarks below	and fully enforced?	□ Yes	□No
For active remediation systems, are the following compone f no, explain in Remarks below	ents in good condition and v	orking prop	erly?
Pumps, and Electrical		□Yes	□No
. Extraction System Pipelines, Valves, Valve Boxes, and	Other Appurtenances	□Yes	□No
ii. Treatment Technology		□ Yes	□No
v. Discharge Structure and Appurtenances		□Yes	□No
. Recovery Wells		□Yes	□No
Do any observations indicate that RAOs are not being met	? If yes, explain in Remarks	Yes	□No
Has land use on- or offsite changed? If yes, explain in Rema	nrks	Yes	□No
Oo monitoring wells at the site appear to be functioning, lo f no, explain in Remarks	ocked and in good condition	? XYes	□No
s the area free of identifiable concerns, such as, signs of delebris, with regards to this site? If no, explain in Remarks	umping of chemicals or	Yes	□No
Are there any previously undocumented features at the site changes in grade)? If yes, note on map; identify any effect on		Yes	□ No
Remarks:			
SITE 36 - RECEATIONAL USE (WOTER ST Way to accus MCAS NEW RIVER	R PICKE AREA	coap) or	14
- NO SIGNS OF PHYSICAL BARN		INTRUS	IVE
ACTIVITIES IN SOME LINE ARECO			
-NO SIGNS WARMING ABOUT	HAZAROUNI WAST	C SITE	
(W)			
	14 - WELL AGANDON		ZJAI
P	PILED BY ENTRANCE	OF SITE	
SITE 54- CONLD NET Arcess Due to	~		
RECOGNERS CONFIRMING EXTENT OF	E CONSTRUCTION WX	A SITE	

Site name: 1,28 (0,7)	Date/Time:: 3/27/14 0900
	ature:
Are institutional controls and LUCs properly implemented and full If no, note on map and explain in Remarks below	ly enforced? □ Yes XNo
For active remediation systems, are the following components in go If no, explain in Remarks below	od condition and working properly?
i. Pumps, and Electrical	□ Yes □ No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other A	ppurtenances
iii. Treatment Technology	□ Yes □ No
iv. Discharge Structure and Appurtenances	□ Yes □ No
v. Recovery Wells	□ Yes □ No
Do any observations indicate that RAOs are not being met? If yes,	explain in Remarks
Has land use on- or offsite changed? If yes, explain in Remarks	¥Yes □ No
Do monitoring wells at the site appear to be functioning, locked and If no, explain in Remarks	d in good condition? □ Yes □ No
Is the area free of identifiable concerns, such as, signs of dumping of debris, with regards to this site? If no, explain in Remarks	of chemicals or Yes 🗆 No
Are there any previously undocumented features at the site (new rechanges in grade)? If yes, note on map; identify any effect on the remo	pads, wetlands, edy in Remarks below
Remarks:	
SITE 28 - PLANGROUND CONSTRUCTED W/	In Non-monthere we
contest Boundary	
- NON-industrial use courses viocates.	- PLAYEROUNO
	7

Site name: Stre 16 (Ch\$)	Date/Time:: 3/27/16	1 1300	
Inspector: K. BRILLEMAN /B 260	Signature: A		
Are institutional controls and LUCs properly implemented a If no, note on map and explain in Remarks below	and fully enforced?	Yes	□No
For active remediation systems, are the following component If no, explain in Remarks below	ts in good condition and wor	king pro	perly?
i. Pumps, and Electrical		□Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and C	Other Appurtenances	☐ Yes	□No
iii. Treatment Technology		□ Yes	□ No
iv. Discharge Structure and Appurtenances		□ Yes	□No
v. Recovery Wells		□ Yes	□No
Do any observations indicate that RAOs are not being met?	If yes, explain in Remarks	YYes	(R)
Has land use on- or offsite changed? If yes, explain in Remark	KS	□ Yes	×No
Do monitoring wells at the site appear to be functioning, loc If no, explain in Remarks	ked and in good condition?	□ Yes	□No
Is the area free of identifiable concerns, such as, signs of dur debris, with regards to this site? If no, explain in Remarks	mping of chemicals or	Yes	□No
Are there any previously undocumented features at the site changes in grade)? If yes, note on map; identify any effect on the state of		□ Yes	XNo
Remarks:			
- Sign Present on GATE - NSOFT of	Fence.		
- Sign Present on CATE - NSOFT OF - ACTESS, IS NOT PROPERTY BY FIRM By FOOT PROPERTY.	secumo whole ch	C	

3/26/14

Site name: SITE 35 (ONIU)	Date/Time: 3/26	F# 16	15
Inspector: K. Barczenan B. REND	Signature: LD		
Are institutional controls and LUCs properly implemented If no, note on map and explain in Remarks below	and fully enforced?	Yes	□No
For active remediation systems, are the following compone If no, explain in Remarks below	ents in good condition and wor	king pro	perly?
i. Pumps, and Electrical		□ Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and	Other Appurtenances	□Yes	□No
iii. Treatment Technology		□ Yes	□No
iv. Discharge Structure and Appurtenances		□ Yes	□No
v. Recovery Wells		□ Yes	□No
Do any observations indicate that RAOs are not being met	? If yes, explain in Remarks	□Yes	XNo
Has land use on- or offsite changed? If yes, explain in Rema	rks	□ Yes	X No
Do monitoring wells at the site appear to be functioning, lo If no, explain in Remarks	cked and in good condition?	□Yes	×No
Is the area free of identifiable concerns, such as, signs of dudebris, with regards to this site? If no, explain in Remarks	umping of chemicals or	X Yes	□No
Are there any previously undocumented features at the site changes in grade)? If yes, note on map; identify any effect on		XYes	□No
Remarks:			
- AIR SPACEE SYSTEM IS OFF			
- MW30 CLUSTER NOT LOCKED / NOT AGE	E TO BE LOCKED		
- SOIL GAS POINT BROKEN (SCO) - ONLY	A PROBLEM IF SI	PARCE.	System
CFTS TWENCE ON			
- Constantion/Bullin Work @ C	5-560 and North	of	

Site name: SITE 80 (OUII)	Date/Time:: 3/27/10	1 09	30
Inspector: K. Barcemon B 2600 Sign	nature: KK		
Are institutional controls and LUCs properly implemented and fu If no, note on map and explain in Remarks below	lly enforced?	□ Yes	≫ No
For active remediation systems, are the following components in g If no, explain in Remarks below	ood condition and wor	king pro	perly?
i. Pumps, and Electrical		□ Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other	Appurtenances	□ Yes	□No
iii. Treatment Technology		□ Yes	□ No
iv. Discharge Structure and Appurtenances		□ Yes	□ No
v. Recovery Wells		□ Yes	□No
Do any observations indicate that RAOs are not being met? If yes,	explain in Remarks	X Yes	□No
Has land use on- or offsite changed? If yes, explain in Remarks		□Yes	No
Do monitoring wells at the site appear to be functioning, locked an If no, explain in Remarks	d in good condition?	□ Yes	□No
Is the area free of identifiable concerns, such as, signs of dumping debris, with regards to this site? If no, explain in Remarks	of chemicals or	X Yes	□No
Are there any previously undocumented features at the site (new r changes in grade)? If yes, note on map; identify any effect on the rem	roads, wetlands, nedy in Remarks below	□ Yes	No
Remarks:			
-NO SIGNS OR BORNICES TO PREVEN INT	PRINTINE WORLE		

Site name: Site 3 (ON 12)	Date/Time:: 3 27 1	4 08	12
Inspector: K Garcie-An B. Re 10 Sign	ature: KR		
Are institutional controls and LUCs properly implemented and ful If no, note on map and explain in Remarks below	ly enforced?	Yes	□No
For active remediation systems, are the following components in go If no, explain in Remarks below	ood condition and wor	king pro	perly?
i. Pumps, and Electrical		□ Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other A	ppurtenances	☐ Yes	□No
iii. Treatment Technology		□ Yes	□ No
iv. Discharge Structure and Appurtenances		□ Yes	□ No
v. Recovery Wells		□ Yes	□No
Do any observations indicate that RAOs are not being met? If yes,	explain in Remarks	Yes	□No
Has land use on- or offsite changed? If yes, explain in Remarks		☐ Yes	N No
Do monitoring wells at the site appear to be functioning, locked an If no, explain in Remarks	d in good condition?	Yes	□No
Is the area free of identifiable concerns, such as, signs of dumping debris, with regards to this site? If no, explain in Remarks	of chemicals or	X Yes	□No
Are there any previously undocumented features at the site (new rechanges in grade)? If yes, note on map; identify any effect on the rem	oads, wetlands, edy in Remarks below	□ Yes	₹ No
Remarks:			

Site name: Site 63 (OU 13)	Date/Time:: 3/26/6	4 171	5
Inspector: K. BONCHOAN B. REID	Signature:		-
Are institutional controls and LUCs properly implemented an If no, note on map and explain in Remarks below	d fully enforced?	Yes	□No
For active remediation systems, are the following components If no, explain in Remarks below	in good condition and wor	king proj	perly?
i. Pumps, and Electrical		□ Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Ot	her Appurtenances	☐ Yes	□No
iii. Treatment Technology		☐ Yes	□ No
iv. Discharge Structure and Appurtenances		□ Yes	□No
v. Recovery Wells		☐ Yes	□No
Do any observations indicate that RAOs are not being met? If	yes, explain in Remarks	□ Yes	No
Has land use on- or offsite changed? If yes, explain in Remarks		□Yes	Ø No
Do monitoring wells at the site appear to be functioning, locked If no, explain in Remarks	d and in good condition?	□ Yes	□No
Is the area free of identifiable concerns, such as, signs of dump debris, with regards to this site? If no, explain in Remarks	oing of chemicals or	X Yes	□No
Are there any previously undocumented features at the site (n changes in grade)? If yes, note on map; identify any effect on the		□Yes	No
Remarks:			
	And the second s		

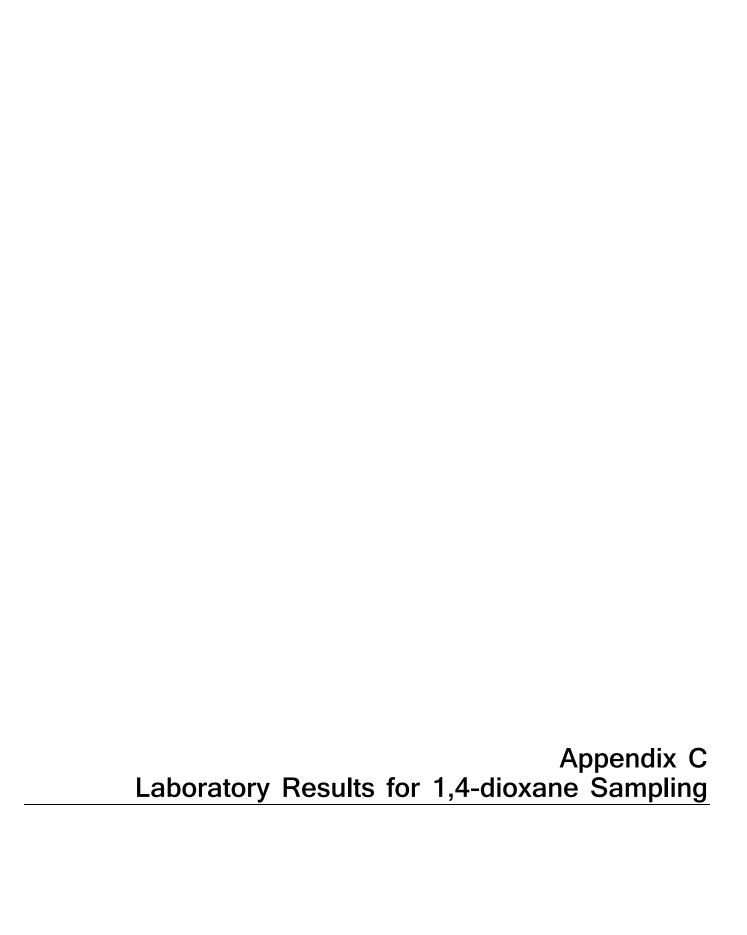
Site name: Str 89 , 93 (OU 16)	Date/Time:: 3/26/1	1 160	0
Inspector: K. Beickman B. REID	Signature: & R_		
Are institutional controls and LUCs properly implemented at f no, note on map and explain in Remarks below	nd fully enforced?	XYes	□No
For active remediation systems, are the following components f no, explain in Remarks below	in good condition and wor	king pro	perly?
. Pumps, and Electrical		YYes	□No
i. Extraction System Pipelines, Valves, Valve Boxes, and O	her Appurtenances A	□ Yes	□ No
ii. Treatment Technology		□ Yes	No
v. Discharge Structure and Appurtenances MA		□Yes	□No
v. Recovery Wells		□ Yes	□No
Do any observations indicate that RAOs are not being met? I	f yes, explain in Remarks	□ Yes	×No
Has land use on- or offsite changed? If yes, explain in Remarks		□ Yes	XNo
Do monitoring wells at the site appear to be functioning, lock If no, explain in Remarks	ed and in good condition?	¾ Yes	□No
Is the area free of identifiable concerns, such as, signs of dum debris, with regards to this site? If no, explain in Remarks	ping of chemicals or	Yes	□ No
Are there any previously undocumented features at the site (changes in grade)? If yes, note on map; identify any effect on the		□'Yes	ΧNo
Remarks:			
SITE 89			
- AS ACROTION SISTENI IN PLACE & RUDNIN	a Prepency		
- AS, ACROTION SISTEMS IN PLACE & RUPHING - OBSCRUED GROWNOWPOTER APPRICLING FRO	M PRO AREA (M	w96)	
SIGNAGE RECOMMENDED TO PERCHIBIT AC			EA E. OF
SIN93 - OK			

Site name: SITE 84 (OU.19)	Date/Time:: 3 /2 14 1600
Inspector: K. BRICKMAN B. RED Sign	ature: KB
Are institutional controls and LUCs properly implemented and full If no, note on map and explain in Remarks below	ly enforced?
For active remediation systems, are the following components in go If no, explain in Remarks below	ood condition and working properly?
i. Pumps, and Electrical	☐ Yes ☐ No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other A	appurtenances
iii. Treatment Technology	□ Yes □ No
iv. Discharge Structure and Appurtenances	□ Yes □ No
v. Recovery Wells	□ Yes □ No
Do any observations indicate that RAOs are not being met? If yes,	explain in Remarks XYes INo
Has land use on- or offsite changed? If yes, explain in Remarks	□ Yes ➤ No
Do monitoring wells at the site appear to be functioning, locked and If no, explain in Remarks	d in good condition? ☐ Yes ☐ No
Is the area free of identifiable concerns, such as, signs of dumping of debris, with regards to this site? If no, explain in Remarks	of chemicals or Yes 🗆 No
Are there any previously undocumented features at the site (new rochanges in grade)? If yes, note on map; identify any effect on the reme	oads, wetlands, edy in Remarks below
Remarks:	
- NEW CONSTRUCTION OF PHOTOVOURAGE F	ARM in STITE 84
MASTE SITE	NS RELATED TO HAZ

Site name: SITE 86 (CN20) Date/Time:: 3/26/16	1 12	16
Inspector: K. Barereman B. REID Signature: & B		
Are institutional controls and LUCs properly implemented and fully enforced? If no, note on map and explain in Remarks below	Yes	□No
For active remediation systems, are the following components in good condition and wor If no, explain in Remarks below i. Pumps, and Electrical	king proj	perly?
ii. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances	□ Yes	□ No
iii. Treatment Technology	□ Yes	□ No
iv. Discharge Structure and Appurtenances	□ Yes	□No
v. Recovery Wells	□ Yes	□No
Do any observations indicate that RAOs are not being met? If yes, explain in Remarks	☐ Yes	No
Has land use on- or offsite changed? If yes, explain in Remarks	□ Yes	SeNo
Do monitoring wells at the site appear to be functioning, locked and in good condition? If no, explain in Remarks	XYes	□ No
Is the area free of identifiable concerns, such as, signs of dumping of chemicals or debris, with regards to this site? If no, explain in Remarks	Yes	□No
Are there any previously undocumented features at the site (new roads, wetlands, changes in grade)? If yes, note on map; identify any effect on the remedy in Remarks below	XYes	□ No
Remarks:		
Construction @ MCAS N.R. Sherounding 8G		
		- 17

ite name: Site 73 (Oh23) Date/Time:: 3/26/14 1810			
Inspector: K. BRICKMAN B. REID S	nature:		
Are institutional controls and LUCs properly implemented and If no, note on map and explain in Remarks below	fully enforced? Yes No		
For active remediation systems, are the following components in If no, explain in Remarks below	good condition and working properly?		
i. Pumps, and Electrical	□ Yes □ No		
ii. Extraction System Pipelines, Valves, Valve Boxes, and Othe	r Appurtenances №A □ Yes □ No		
iii. Treatment Technology	Yes □ No		
iv. Discharge Structure and Appurtenances NA	□ Yes □ No		
v. Recovery Wells	□ Yes □ No		
Do any observations indicate that RAOs are not being met? If yo	es, explain in Remarks 🗆 Yes 🕱 No		
Has land use on- or offsite changed? If yes, explain in Remarks	□ Yes ⋈ No		
Do monitoring wells at the site appear to be functioning, locked If no, explain in Remarks	and in good condition? ☐ Yes ➤ No		
Is the area free of identifiable concerns, such as, signs of dumpir debris, with regards to this site? If no, explain in Remarks	ng of chemicals or Yes □ No		
Are there any previously undocumented features at the site (new changes in grade)? If yes, note on map; identify any effect on the re	v roads, wetlands, emedy in Remarks below		
Remarks:			
- ALL INSECTION WELLS KNOCKTED			
- MW 53 CENSTER DID NOT HAVE CASING WAS DAMAGED	& PROTRITUE OWER CASUR		

Site name: SITE 49 (ON23)	Date/Time:: 3 26 10	Date/Time:: 3 26 14 1230	
Inspector: K. BRICKMAN B. REID S	Signature: Ka	,	
Are institutional controls and LUCs properly implemented and If no, note on map and explain in Remarks below	I fully enforced?	Yes	□No
For active remediation systems, are the following components in If no, explain in Remarks below	n good condition and wor	king proj	perly?
i. Pumps, and Electrical		□ Yes	□No
ii. Extraction System Pipelines, Valves, Valve Boxes, and Oth	er Appurtenances	□ Yes	□No
iii. Treatment Technology		□Yes	□No
iv. Discharge Structure and Appurtenances		□ Yes	□No
v. Recovery Wells		□Yes	□No
Do any observations indicate that RAOs are not being met? If y	ves, explain in Remarks	□ Yes	No
Has land use on- or offsite changed? If yes, explain in Remarks		□ Yes	XNo
Do monitoring wells at the site appear to be functioning, locked If no, explain in Remarks	and in good condition?	¥Yes	□No
Is the area free of identifiable concerns, such as, signs of dumpi debris, with regards to this site? If no, explain in Remarks	ing of chemicals or	□Yes	XNo
Are there any previously undocumented features at the site (ne changes in grade)? If yes, note on map; identify any effect on the		□Yes	No.
Remarks:			
- BATTERIES (CAR) AND TRASH PILED BY	1 BLD. AS 810 1	DIACE	ext.
TO SITE. NOTH WIST SIDE OF BUILD			
Telegraphic and the control of the c			





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Region 4

Science and Ecosystem Support Division 980 College Station Road Athens, Georgia 30605-2720

MEMORANDUM

Date: 12/02/2002

Subject: Results of VOLATILES Sample Analysis

03-0060

USMC Camp LeJeune

Jacksonville, NO

From: Allen, Frank

To: Townsend, Gena

CC: Rick Raines

USMC

Thru: Cosgrove, Bill

Chief, Organic Chemistry Section

Analytical Support Branch

Attached are the results of analysis of samples collected as part of the subject project. If you have any questions, please contact me.

Sample Disposal Policy:

According to our records this project is not part of a criminal investigation. Because of our limited space for long term sample storage, we must perform disposals on a routine basis.

Therefore, please take note that within 90 days of the date of this memo, the original samples and all extracts associated with the samples will be disposed of as required by all applicable and appropriate statutes.

These samples may be held in custody for longer than 90 days only by contacting our sample coordinator, Debbie Colquitt, by e-mail at Debbie.Colquitt@epa.gov.

ATTACHMENT

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

418 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: TB09-02D /

Media: TRIP BLANK - WATER

Jacksonville, NC

Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/24/2002 15:00

Ending:

RESULTS UNITS **ANALYTE** 10 U UG/L 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Page 1 of 1

Sample

419 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: GW15-02D / IR73 Media: GROUNDWATER

Jacksonville, NC

Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/24/2002 13:10

Ending:

RESULTS UNITS ANALYTE 10 U UG/L 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

420 FY 2003 Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Jacksonville, NC

Program: SF

Id/Station: 141W-02D / IR69-GW141W

Media: GROUNDWATER

RESULTS UNITS 10 U UG/L

ANALYTE 1,4-DIOXANE Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/24/2002 11:15

Ending:

A-average value. NA-not analyzed. NAI-interferences, J-estimated value. N-presumptive evidence of presence of material. K-actual value is known to be less than value given. L-actual value is known to be greater than value given. U-material was analyzed for but not detected, the number is the minimum quantitation limit. R-qc indicates that data unusable, compound may or may not be present, resampling and reanalysis is necessary for verification. Page 1 of 1

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

421 FY 2003 Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: GW14-02D / IR69 Media: GROUNDWATER

Jacksonville, NC

Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/24/2002 09:05

Ending:

RESULTS UNITS ANALYTE 10 U UG/L 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

422 FY 2003

Project: 03-0060

Produced by: Allen, Frank

Requestor:

Facility: USMC Camp LeJeune

Jacksonville, NC

Project Leader: GTOWNSEN Beginning: 10/24/2002 12:45

Program: SF

Id/Station: 47DW-02D / IR73-GTW47DW

Ending:

Media: GROUNDWATER

RESULTS UNITS 10 U UG/L

SPECIFIED TESTS

ANALYTE 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

423 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: GW05-02D / IR93 Media: GROUNDWATER

Jacksonville, NC

Requestor:

Project Leader: GTOWNSEN Beginning: 10/23/2002 16:05

Produced by: Allen, Frank

Ending:

RESULTS UNITS ANALYTE 10 U UG/L 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

424 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Jacksonville, NC

Program: SF

Id/Station: 051W-02D / IR93-GW051W

Media: GROUNDWATER

RESULTS UNITS 10 U UG/L ANALYTE 1,4-DIOXANE Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/23/2002 16:45

Ending:

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

425 FY 2003

Project: 03-0060

Jacksonville, NC

Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN

Beginning: 10/23/2002 10:45

Ending:

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: GW03-02D / IR36 Media: GROUNDWATER

RESULTS UNITS 10 U UG/L

ANALYTE 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

426 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: 061W-02D / IR89-GW061W

Media: GROUNDWATER

Jacksonville, NC

Produced by: Allen, Frank Requestor:

Project Leader: GTOWNSEN

Beginning: 10/23/2002 13:40

Ending:

RESULTS UNITS ANALYTE 10 U UG/L 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

427 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: GW04-02D / IR89 Media: GROUNDWATER

Jacksonville, NC

Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/23/2002 12:15

Ending:

RESULTS UNITS ANALYTE 10 U UG/L 1,4-DIOXANE

A-average value. NA-not analyzed. NAI-interferences. J-estimated value. N-presumptive evidence of presence of material. K-actual value is known to be less than value given. L-actual value is known to be greater than value given. U-material was analyzed for but not detected, the number is the minimum quantitation limit. R-qc indicates that data unusable, compound may or may not be present, resampling and reanalysis is necessary for verification. Page 1 of 1

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

428 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Jacksonville, NC

Program: SF

Id/Station: 101W--02 / IR36-GW101W-

Media: GROUNDWATER

RESULTS UNITS 10 U UG/L

ANALYTE 1,4-DIOXANE Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/23/2002 09:45

Ending:

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Sample

429 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Program: SF

Id/Station: 551W02D / IR35-GW551W

Media: GROUNDWATER

Jacksonville, NC

Project Leader: GTOWNSEN Beginning: 10/23/2002 14:05

Produced by: Allen, Frank

Ending:

Requestor:

RESULTS UNITS 10 U UG/L

ANALYTE 1,4-DIOXANE

EPA - REGION IV SESD, ATHENS, GA

Production Date: 12/02/2002 11:14

Page 1 of 1

Sample

430 FY 2003

Project: 03-0060

SPECIFIED TESTS

Facility: USMC Camp LeJeune

Jacksonville, NC

Program: SF

Id/Station: GW55-02D / IR35 Media: GROUNDWATER

Produced by: Allen, Frank

Requestor:

Project Leader: GTOWNSEN Beginning: 10/23/2002 13:00

Ending:

RESULTS UNITS **ANALYTE** 10 U UG/L 1,4-DIOXANE